SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1920.

GENERAL PHYSICS.

653. *Harmonic Synthetiser.* **J. R. Milne.** (Roy. Soc. Edinburgh, Proc. 39. pp. 234–242, 1918–1919.)—The present paper is a continuation of one published previously [Abs. 1806 (1906)]. It is here shown that by a slight alteration, the simple form of mechanism proposed by Kelvin in 1881, but afterwards rejected by him on account of "obliquity error," can be made quite satisfactory. It was found that a "duplex" disposition of the pulleys of the apparatus, entailing no additional parts, but re-arrangement only, would very nearly annul the error altogether. A. W.

654. *Recording Submarine Depthmeter.* **G. Cook.** (Engineering, 109. p. 333, March 12, 1920.)—The instrument described was designed to indicate the depth of a "kite," or of any part of a sweep wire, under specified conditions in mine-sweeping operations. It was necessary for each instrument to be self-contained, and capable of recording the depth continuously over a sufficient length of time. In order to affect as little as possible the normal conditions, a stream-line shape was adopted, and the buoyancy was only just sufficient to bring it to the surface in the event of the instrument breaking loose from its attachment. The outer casing consists of three aluminium castings, having a smooth stream-line profile when assembled. The depth-recording mechanism is contained in the central casting, and consists of a piston working against a spring, whose movement was recorded by means of a pencil on a revolving drum. The pressure of the sea-water is admitted to the piston through holes in the tail fins, direct access of the sea-water to the plunger being prevented by the interposition of a thin rubber conical bag filled with a heavy mineral oil. Leakage of this oil past the piston was found to be negligible under the highest pressure. Access to the recording drum is obtained by removing the head, which was held to the body by the towing bracket, the joint being made tight with a rubber ring. Clockwork is used to drive the drum, the speed being regulated by an air-brake so as

to give one revolution in about an hour. The depth scale was obtained by direct calibration in still water by means of a sounding line. The total weight of the apparatus is about 30 lbs., and in water it has a positive buoyancy of from 2 to 3 lbs. A. W.

655. *Surface Tensimeter for Small Quantities of Liquids.* **C. C. Kiplinger.** (Am. Chem. Soc., J. 42. pp. 472–476, March, 1920.)—The instrument described permits of the approximate determination of the surface tension of a drop or two of a liquid and serves as an aid in the identification of organic liquids. It consists of a capillary glass tube 18 cm. long, about 1 mm. bore, and 4 mm. external diameter, broken off carefully so as to obtain a clean right-angled fracture. A quadrant cut from a celluloid protractor is pierced with two holes and the tube attached to one edge of it [see J. Ind. Eng. Chem., 10. 8. p. 631, 1918]. A small notch cut in the apex of the quadrant holds in position a thread which passes over it and is kept taut by weights, and serves to indicate the angular displacement of the tube. A perforated cork supporting a bolt and two grooved cork washers is held in a clamp and carries the tube and its attachments. A glass cap 5 cm. long is fitted over the end of the capillary to retard evaporation of the liquid. A column of the liquid, 1–3 cm. in length (the lower the tension and the greater the density, the shorter should be the column) is introduced into the clean capillary and the latter then turned to such an angle from the vertical that the meniscus at the lower end changes to a plane surface, this being observed with a lens against a sheet of white paper as background. The angle A is then read and checked and the length L of the liquid thread measured to within 1 mm. Then $L \cos A = h$, where h is the height of the vertical column exerting the same downward pressure as the inclined thread of liquid.

The mean results obtained are as follows: water, 71·2 (true value, 72·7); benzene, 26·6 (28·9); and carbon tetrachloride, 24·0 (26·7). By attaching the tensimeter to the stage of a compound microscope and obtaining the angles by tilting the body of the microscope, somewhat better results are obtained, namely: water, 71·6; benzene, 27·5; carbon tetrachloride, 25·5; toluene, 27·2 (28·58); and ethylene dibromide 37·6 (38·73). The uniform lowness of the results may be due partly to the fact that, owing to the flattening of the meniscus, the actual length of the column of liquid may be slightly greater than the distance as measured between the bottoms of the two menisci. T. H. P.

656. *Absolute Measurement of Length Gauges by Optical Means.* **A. Pérard.** (Comptes Rendus, 170. pp. 390–392, Feb. 16, 1920.)—Describes a method for determining the dimensions of Johansson gauges in terms of wave-lengths of monochromatic light. It has been shown previously that the interspace between the surfaces of two gauges is less than two hundredths of a micron, and the method of measurement proposed consists in placing the gauge to be measured in contact with a plane steel surface of greater area than that of the surface of the gauge. Upon the other surface of the gauge is placed a reference plane of glass, and thus, with a beam of monochromatic light, Fizeau's fringes are obtained not only between the gauge and the glass, but also between the steel plate and the glass. Thus, by suitable arrangements described in

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the paper it is possible to deduce the thickness of the gauge. Thicknesses up to 1 cm. can be measured in this way, and even up to 15 mm. measurements are still possible although extremely exacting. J. W. T. W.

657. *Relation Connecting the Derivatives of Physical Quantities.* **M. D. Hersey.** (Bureau of Standards, Bull. 15. pp. 21–29 [Sci. Papers, No. 331], 1919.)—Shows how the theory of dimensions may be used in a differential form. Given a relation between N physical quantities, such that one can be expressed as a function of the remainder, it is shown that it is always possible to obtain a linear equation connecting the differentials of this one function with respect to two of the others (the constants of this equation involving none of the other N—3 quantities), provided certain dimensionless products of the N quantities are held constant. The bearing of this last restriction is discussed fully in the paper, and the method is illustrated by application to three examples, namely: the variation of journal friction with size of bearing, the effect of gravity on a rolling-ball viscometer, and the effect of high pressure on the accuracy of this viscometer. The paper is mainly mathematical and cannot be usefully abstracted. J. W. T. W.

658. *Determination of Laws for Experimental Data.* **H. Cotton.** (Electrician, 84. pp. 368–369, April 2, 1920.)—This paper applies the method of correlation to the problem of the determination of the line whose equation fits best any given set of observations, *i.e.*, the line thus found is that for which the errors are the least. Theory of the method is given. A. W.

659. *Analytical Weighing.* **H. L. Wells.** (Am. Chem. Soc., J. 42. pp. 411–419, March, 1920.)—Weighing by short swings, in preference to long ones, is advocated. It is claimed that the method is accurate and much more simple to carry out than the "preposterously laborious method" of long swings. T. S. P.

660. *Plane Strain: the Direct Determination of Stress.* **S. D. Carothers.** (Roy. Soc., Proc. 97. pp. 110–123, April 1, 1920.)—The advantages of the direct determination of the stresses in an elastic solid have been pointed out by J. H. Michell. The principal line of attack in the case of plane strain has been by aid of the well-known stress function method, by which the stresses are determined from a single stress function, X, of x and y only. The lines along which further advance might have been expected, and the difficulties which have been met with, are discussed by A. E. H. Love. The present paper points out that the stress function method gives a set of stresses which, in most cases, can be resolved into two distinct sets, each of which leads to strains satisfying the identical relations between the strain components. This is then mathematically treated and illustrated by a number of diagrams. E. H. B.

661. *Elastically Supported Beam.* **C. B. Biezeno.** (K. Akad. Amsterdam, Proc. 22. No. 6. pp. 621–632, 1920.)—Describes a method for the graphical determination of the moments of transition of an elastically supported beam. The method is applied in succession to the cases of three, four, and five supports equally spaced and of equal stiffness. J. W. T. W.

662. *Compressibility of Indium.* **T. W. Richards** and **J. Sameshima.** (Am. Chem. Soc., J. 42. pp. 49–54, Jan., 1920.)—Describes experiments to determine the compressibility of indium, cast in the form of short rods 4·5 cm. long and 0·51 cm. in diam. The method employed was that of a mercury piezometer, but owing to the fact that indium amalgamates very readily with mercury it was necessary to protect the indium by an inert liquid, water, which necessitated correction on account of its very great compressibility. The curve of observed values of compressibility was extrapolated by using a long rubber spline bent, by means of forces applied at the extreme ends, so as to fit all the points. The compressibility at 25° over the range 100 to 500 megabars was found to be 0·0000027, or about two-thirds that of mercury. J. W. T. W.

663. *Photographic Measurement of Resistance to Rolling.* **J. Andrade.** (Comptes Rendus, 170. pp. 225–226, Jan. 26, 1920.)—In 1780, Euler published the solution to a problem concerning the rolling of one cylinder inside a larger one under the action of gravity, the generators of the two cylinders being horizontal and parallel. Modified in its enunciation and completed by evaluation of the resistance to rolling, Euler's exercise suggests a method for the accurate measurement of resistance to rolling, based upon the photographic recording of oscillations. A fixed cylinder has a radius a, less than the internal radius b of a cylindrical ring which rolls on its spindle placed horizontally. Equations of motion are given in the paper for the oscillations of the ring. The angular displacement f of the apparent dead-point of each simple oscillation is given by $f = \delta b/[b^2 + c(b-a)]$, where δ = linear coefficient of resistance to rolling, and c = distance between centre of gravity of the ring and its geometrical axis. If $c = \theta$, $f = \delta/b$ and is independent of a. The angle θ, between the vertical and the common perpendicular to the axes of the two cylinders, is determined by photographing the displacement of the centre point of the ring. When boring the latter, two points are marked diametrically opposite on its rim, and these points are made the supports of a light frame carrying a lamp and objective. This device records the oscillations on a falling photographic plate. The resistance of the air is proportional to the speed $d\theta/dt$ and the photographic record is interpreted as that of a double, damped oscillation. R. E. N.

664. *Pendulum Oscillations as influenced by Deformation of Knife-edge.* **P. Le Rolland.** (Comptes Rendus, 170. pp. 455–457, Feb. 23, 1920.)—It is found that at the moment when a pendulum passes the vertical the centre of rotation is suddenly displaced in the direction of motion. Thus alone is it possible to explain the variation in the period of oscillation under varying conditions. Knife-edges of glass, copper, aluminium, and lead are used.

A complete theory of the pendulum takes into account not only this displacement of the edge, but also allows for the fact that the motion at the edge is really that of a cylinder rolling with friction on a plane. P. E. S.

665. *Earth Pressures.* **H. G. Moulton.** (Am. Inst. Mining Eng., Bull. No. 158 [25 pp.], Feb., 1920.)—Three types of material are distinguished according to their behaviour, under load. 1. More or less *coherent materials,* capable of standing to a certain depth with a vertical

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face. At greater depths they will fail in shear in exactly the same manner and leave the same shape of bank after failure. A great number of materials are considered from their behaviour as shown by engineering works. Plans of fracture in excavations, tunnels, quarries, and mines are given, showing that practically all rock materials, including clay and firm sand, give way by shear along a plane inclined at 70° to the horizontal. 2. *Granular materials* without cohesion between the separate grains. Such lie at the angle of repose. 3. *Semi-liquid materials.* Such are quicksand and wet clay. They will stand considerable deformation without rupture, and are to be considered from the standpoint of hydrostatics. W. A. R.

666. *Recording of Eiffel Tower Time-Signals for Determination of Clock Error.* **L. B. Turner.** (Electrician, 83. pp. 554–557, Nov. 14, 1919.)—Using the "Scientific" time signals sent out at about 11.30 p.m. from the Eiffel Tower, a skilled observer can compare his chronometer with Eiffel Tower time to within about 0·1 sec. by the method of coincidences, using merely an auditive receiver. When atmospherics are pronounced, however, it is necessary to produce an automatic simultaneous record of the chronometer indications and the time signals. Subsequent study of the record enables one to distinguish between time signals and atmospherics, and to measure up time intervals to within 0·01 sec. or so. The present paper describes, with several diagrams, apparatus constructed at the Signals Experimental Establishment, Woolwich, for producing the above simultaneous record. For recording the time signals a valve relay, to be described more fully in a later paper, was used. This, when tripped by a wireless signal, energises, through an ordinary Post Office relay, one indicating magnet of a double chronograph; the other magnet of this chronograph is energised at one-second (or other) intervals by an electric contact in the clock whose error is to be determined. Time records are thus obtained on a single slip, which can subsequently be used to determine accurately the discrepancy between the two sources of time indications. Two patterns of chronograph have been used: the common astronomical Hilger chronograph, which gives ink records; and the Lindquist chronograph in which the records are made by two sharp points which puncture the slip at the beginning of the signal. The latter is particularly suitable for survey work on account of its compactness and the avoidance of ink. Special determinations were made of the time lag in the wireless relay apparatus. Typical records are reproduced. A. W.

667. *Efflux of Gases through Small Orifices.* **E. Buckingham** and **J. D. Edwards.** (Bureau of Standards, Bull. 15. pp. 573–615 [Sci. Papers, No. 359], 1920.)—Gives the results of experiments on the rate of efflux of various gases (air, H, CH_4, CO_2, Ar) through small orifices 0·05 to 0·09 mm. in diam. Equations are developed to represent the experimental results, on the assumption that for any given diam. of orifice, the minimum section of the jet is the same for air as for the test gas. On this assumption hydrogen shows a systematic divergence probably due to a difference in the form of the jets for hydrogen and for air. The apparatus with which the measurements were made is described in detail, and the results obtained are shown graphically in the paper. J. W. T. W.

668. *Inertia of an Immersed Sphere.* **G. Cook.** (Phil. Mag. 39. pp. 350–352, March, 1920.)—Stokes showed that when a solid body moves in a frictionless fluid of infinite extent, the effect of the fluid pressure is equivalent to an increase in the inertia of the body. The effect is manifest in cases of accelerated or retarded motion, and has direct application to the theory of the oscillating mine. In the case of a sphere analysis shows that the increase of inertia is one-half of the mass of the displaced fluid. Experiments to verify the theory are described, which show the increase in inertia to be 0·46 times the displacement. W. A. R.

669. *Testing Ball Bearings.* **T. Y. Baker.** (Optical Soc., Trans. 20. pp. 343–344, June, 1919.)—In the Admiralty gyro-compasses the main gyro-wheel weighs 50 lbs. and runs at a speed of 8600 r.p.m. It is essential that the ball bearings supporting the axle of this wheel should run concentrically to 1/10,000 in., else the wheel will not run true. An instrument is described for measuring the eccentricity. To do this a kind of optical lever is employed consisting of two parallel mirrors and another mirror inclined at 45° to them. An auto-collimating telescope is used for observing the angular movement of the optical lever caused by the running of the ball bearings. P. E. S.

670. *Gliding Flight of Birds.* **P. Idrac.** (Comptes Rendus, 170. pp. 269–272, Feb. 2, 1920.)—Describes some experiments undertaken in order to determine the conditions allowing of the sustentation of a bird without any apparent movement of the wings. It is found that in every case where this takes place the air current has an upward component, and although the bird may pass through regions where this is not the case, it can afford to lose altitude in passing through such a region, and will regain it in the next region with upward current. J. W. T. W.

671. *Gravitation and Temperature Changes.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 547–550, Dec., 1919.)—This describes the variation in the readings of a gravitation needle from day to day as the air temperature varies. P. E. S.

672. *Determination of the Orientation of the Rows and of the Reticular Planes of a Crystal.* **F. Canac.** (Comptes Rendus, 170. pp. 113–116, Jan. 12, 1920.)—The author describes a simple method of determining quickly the reflecting plane of a crystal which corresponds to a given spot in the photograph obtained when a beam of X-rays is passed through a crystal. The method consists in transmitting through the crystal a beam of "white light" X-rays making an angle of several degrees with the row (*rangée*) to be studied. The reticular planes passing through this row give the reflected rays of which the distribution is characteristic. A. B. W.

673. *Determination of the Axes of Symmetry of a Cubic Crystal.* **F. Canac.** (Comptes Rendus, 170. pp. 276–278, Feb. 2, 1920.)—In a previous paper [see preceding Abs.] the author has shown how to determine the orientation of the reticular planes relative to a given axis. A particular study is now described relating to the distribution of reticular planes around the axis of symmetry of the space-lattice of a cubic crystal. A. B. W.

674. *Electrical Nature of the Cohesion Forces of Solid Bodies.* **M. Born.** (Ann. d. Physik, 61. 1. pp. 87–106, Jan. 8, 1920.)—The elastic compressibility of the halogen salts of univalent metals can be explained on the assumption [see Abs. 528 (1919)] that the ions attract or repel according to the Coulomb laws corresponding to their charges, and that a force of repulsion acts between any two ions whose potential is inversely proportional to the ninth power of the distance apart. This hypothesis receives further extension in the present paper, the object of which is to derive all the remaining physical properties of such crystals from the given hypothesis of molecular forces. Should this be successful, a stage further will have been gained in the direction of the electrical conception of matter. The binary halogen salts of the type NaCl are again used, these being the purest form of heteropolar compounds, their atomic forces having been established as electrostatic. Unfortunately, the number of physical constants which may be calculated is not great, but for regular crystals includes the following [see Abs. 295 (1919)] :—(1) A long-wave ultra-red special frequency ω ; (2) the contribution of this ultra-red oscillation to the dielectric constant $\epsilon - \epsilon_0$; (3) three elasticity constants c_{11}, c_{12}, c_{44} (where c_{11} or c_{12} may be replaced by the compressibility κ) ; (4) with asymmetric crystals a constant e_{14} of the polar piezoelectricity. The object of the paper is therefore to calculate the frequency ω and the elasticity constants c_{11} and c_{12} from the atomic force hypothesis. The data from which these magnitudes are evaluated are :—(i) The masses of the two atoms ; (ii) the electric quantum element e ; (iii) the lattice constant δ. Section 1 of the paper investigates the equilibrium condition. Section 2 considers compressibility. Section 3 deals with the special ultra-red oscillation, and section 4 with the elasticity constants. The various formulæ are collected together in section 5. A comparison of results with measurements is given in section 6. An appendix contains a calculation of the electrical alternating effect between the atoms. Unfortunately the experimental data, particularly with respect to the elasticity constants, is too meagre to afford other than a limited proof of the formulæ, otherwise it suffices to support the conception of the electrical nature of the cohesion forces.

H. H. Ho.

675. *Tensor Geometry in the General Theory of Relativity.* **H. Lang.** (Ann. d. Physik, 61. 1. pp. 32–68, Jan. 8, 1920.)—This paper, which is entirely mathematical, contains the following nine sections :—(1) General measurements in a rectilinear system of coordinates, contravariants and covariant coordinates, and vector components. (2) The special symmetrical tensor of the order formed from a four-dimensional vector and its geometrical representation. (3) Geometrical representation of the corresponding general symmetrical tensor. (4) The invariants of this tensor. (5) Geometrical definition of its components. (6) Geometrical definition of the divergence of this tensor. (7) An integral hypothesis of the tensor, and the integral form of the impulse-energy equations in the general theory of relativity. (8) Geometrical representation and divergence of the unsymmetrical tensor of the second order. (9) Definition of the divergence of the tensor of the nth order. H. H. Ho.

676. I. *The Scalar Gravitational Potential.* II. *Curvature of Light Rays due to Gravitation.* III. *Point Motion in the General Gravitational*

Field. **E. Reichenbächer.** (Ann. d. Physik., 61. 1. pp. 1–31, Jan. 8, 1920.)—The first paper deals with the general case of space-time distortion by gravitation. On Einstein's theory, mass density is found to be, not a scalar quantity, but one of the components of a tensor whose other components are very small. This circumstance, together with the fact that the $g_{\mu\nu}$ are of a limited arbitrary character due to their dependence on the choice of a system of coordinates, has led the author to propose a theory of scalar gravitational potential [see Abs. 532 (1917)], identified with the velocity of light, and including definite conceptions of gravitational disturbance by electrons. The general case is discussed of the disturbing effect produced by an additional electron on the usual space-time conception, following which the influence of distortion on curvature is considered.

Paper II deals with the bending of light as a consequence of gravitation. Einstein has established, as a consequence of his gravitational theory, that the curvature of a light ray tangential to the sun is of the order $1 \cdot 7''$. Eddington has maintained that half of the Einstein-effect is given by the gravitational action of the sun on the moving light-energy, so that the effect upon an energy point is the same as upon a mass point. The present author now establishes that the bending of the light ray can be derived from his theory set forth in a previous paper on electricity and gravitation [see Abs. 532 (1917)]. He shows the path of the light ray to approximate very closely to a hyperbola of very great eccentricity. This paper concludes with a discussion of the results obtained and a comparison with those of Einstein.

Paper III deals with point motion in the general gravitational field. It is found, as in Einstein's theory, that under the influence of gravitation in the absence of other forces, the isogonic lines in the distorted system are geodetic lines. H. H. Ho.

677. *Secular Earth Movements.* **E. O. Ulrich.** (Washington Acad. Sci., J. 10. pp. 57–78, Feb. 4, 1920.)—The marginal parts of continents have in recent geologic ages suffered both positive and negative displacements of the strand-line. The vertical element of these oscillations is not uniform in amount at different places. The differential character of Pleistocene to recent movements suggests that they were not *wholly* due to either alternate storing and unloading of water in the form of land ice, nor to retreats caused by periodic deformation of ocean basins by deposition of land detritus. So far as these agents are concerned an even rise or fall over considerable areas should have resulted, whereas there is differential change over short distances. Similar movements can be traced in every geologic period. A comparison of a series of palæogeographic maps show clearly variations in the outlines of successive continental seas that would have been impossible if the land surfaces had not been subject to frequent oscillation and warping. The conclusion is reached that the major factors in the control and migration of the strand-line lie, and have always lain, in deformative movement *within* the lithosphere. And this movement, whether due to crustal shrinkage, local changes in crustal density, unequal loading by rock or ice, is primarily connected with the maintenance of isostasy. W. A. R.

678. *Annual Term in Right Ascensions.* II. **M. L. Zimmer.** (Astron. J. 32. pp. 169–172, March 11, 1920.)—The hopes expressed in the

first paper [Abs. 401 (1919)] of obtaining by the end of 1918 sufficient data for a complete solution have been disappointed owing to very bad weather, but the results so far obtained are given now (Oct. 1919). Stars appear to transit relatively earlier in the daytime, and near noon possibly earlier than near twilight. This effect can be eliminated by observing "twelve-hour" groups when both ends of the group are in daylight or both in darkness. There still remains something which is not yet explained. Lateral refraction is suggested, but this is not satisfying, as the error is different for stars quite near each other, and there appears also to be a difference between A.M. and P.M. observations. Apparently it will be necessary either to find the true explanation so as to correct for it, or else to plan the observations so as to eliminate it. The same twelve-hour groups, observed at 6-month intervals, if all the stars could be equally well observed each time, should secure this. At Cordoba some 10,000 observations for this express purpose have been made in 12 months, not well distributed, most of them being near equinoxes or solstices. The curve of inequality is probably a sine-curve, and a discussion is promised later. Meanwhile no definite explanation is offered. Parallax could account for it, but no known parallax is great enough, so that the problem is quite unsolved, though the author considers its solution of prime importance. W. W. B.

679. *Gauss' Method of Computing Secular Perturbations.* **H. Andoyer.** (Comptes Rendus, 170. pp. 418–420, Feb. 23, 1920.)—The method originated by Gauss by which the first-order terms of planetary inequalities of long period are expressed as elliptic integrals, has been improved from time to time, one of the most recent modifications being that of Innes, who reduces the whole to two functions of the form of hypergeometric series. The present author claims to have found an alternative scheme with two new series of rapid convergence and appends a skeleton table to give the small corrections necessary. W. W. B.

680. *Einstein's Predicted Shift of Solar Spectrum Lines.* **J. Evershed.** (Observatory, 43. No. 551. pp. 153–157, April, 1920.)—The author gives a short *résumé* of results noted in Kodaikanal Observatory Bulletins concerning the absence of pressure shift of anything like the quantity sought, and gives a summary of his Venus results, which appear to indicate an earth-effect on the sun, and a complete disagreement with Einstein's hypothesis. The general result of measures of cyanogen bands and metallic lines (Ni, Ti, etc.), shows a general displacement of the lines at the sun's limb, of the right sign for Einstein's prediction and of a magnitude of the right order. This cannot be explained by pressure shift, and if it is due to motion involves an earth-effect on the sun. But the shift is different for different substances and even for different lines of the same substance. Therefore, if Einstein is right there is some modifying action present. The question is thus left open, and the author asks for independent evidence as to the Venus measures. W. W. B.

681. *New Method of Determining the Solar Constant.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 6. pp. 4–7, Jan., 1920.)—For some years the Smithsonian observers have been investigating apparent short-period variations in the solar radiation. For this purpose very accurate values of the radiation received outside the earth's atmosphere are required.

These, however, are very hard to get, on account of the varying transparency of the atmosphere [see Abs. 26 and 1479 (1919)]. They now employ the pyranometer to determine the brightness of the whole sky, or any fraction of it, on the principle that haziness increases the brightness of the sky but diminishes the transparency. From a spectrum energy curve the quantity of humidity between the observer and the sun can be obtained, which affects the haziness, as well as the dust taken up by wind or scattered from volcanoes does. A function is found to represent this characteristic, and can be evaluated in ten minutes. Observations taken at Calama, Chile, on 60 days were used in testing the new method. A comparison of 53 days' data, when both methods were employed, shows very little difference between them, except on days when, owing to the changing transparency, the old method was unsatisfactory; further, the new method can be used on many more days than the old. For both reasons therefore, increased accuracy and saving of time, the new method will be adopted in solar constant determinations. W. W. B.

682. *Solar Spectrum in the Region* **9000–9900 Å. K. Burns.** (Lick Observat., Bull. 10. [Circ. No. 327]. pp. 64–66, 1920.)—No lines were identified beyond 9000 Å. in the solar spectrum by Meggers [see Abs. 631 (1918)], nor by Abney. Wave-lengths of lines in this region belonging to Fe and associated elements have been determined in the laboratory, and the author has used the grating spectrograph on the great 36-in. Lick refractor in order to identify solar lines and distinguish them from terrestrial. Using Seed 23 plates sensitised with dicyanin, and interposing various screens to reduce scattered red light and Lyman ghosts, lines of intensity 0 on Rowland scale are readily shown, and fainter ones probably down to intensity 00. No lines of certainly solar origin could be identified, all the strong lines proving by comparison of E. and W. limb with Hartmann's stereocomparator to be telluric. Probably the chief interest of the region will not be solar, but the author hopes that a more suitable selective screen may be found. W. W. B.

683. *New Infra-Red Lines in the Solar Prominence Spectrum.* **K. Burns.** (Lick Observat., Bull. 10 [Circ. No. 327], p. 67, 1920.)—The apparatus and method of the preceding paper [see preceding Abs.] were applied to photograph prominence spectrum in the region 6500–9200 Å. Of the He lines, 6678 Å. does not show, being apparently weaker in prominences than in the chromosphere, but 7065 Å. is very strong in prominences though weak in the chromosphere. The Ca triple 8498 Å., 8542 Å., 8662 Å. is shown: the second member strong, the first weaker than the third. No lines were found beyond the Mg line 8807 Å. None of the prominences photographed was very brilliant. The intensity of sky spectrum relative to that of the sun falls off very rapidly towards the red so that if any strong coronal lines were present they should have been easily seen. W. W. B.

684. *Effective Temperature of the Sun.* **H. Groot.** (K. Akad. Amsterdam, Proc. 22. No. 6. pp. 616–620, 1920.)—In a previous paper [see Abs. 54 (1920)] the author gave results in disagreement with certain preconceived notions, and promised a discussion of their meaning. He now deals with the difficulty of even defining the effective temperature of the sun, which, he says, is understood to be that of an absolutely black

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body that would behave in the same way as the sun in regard to temperature. This, however, does not specify whether the equivalence is to be in the value of the solar constant or in the intensity curve of the spectrum. He points out the difference of the value of the effective temperature that will be derived, on the one hand, from Wien's law, and on the other by the Stefan-Boltzmann formula. While, however, still maintaining that Defant's reliance on Planck's formula is unjustified since we are not dealing with a single photospheric surface, he admits that his own expectation that effective temperature would increase with wave-length, so that red light would come from deeper layers, is also untenable. He gives some hypothetical curves of radiation intensity, but considers that the temperature of any layer of the sun cannot be determined until the power of emission of successive layers and also of scattering and absorption can be found. Meanwhile, he says, the so-called "effective temperature" is of very little value, and gives no real clue to any temperatures actually prevailing in the sun. W. W. B.

685. *Total Solar Eclipse, May* 29, 1919. **C. G. Abbot** and **A. F. Moore.** (Astrophys. J. 51. pp. 1–3, Jan., 1920.)—The Smithsonian Institution expedition, stationed at El Alto, Bolivia, obtained two very good photographs of the corona, showing many narrow streamers extending nearly two diameters in almost every direction, and a great sickle-shaped prominence. The corona was of intermediate type. Details of the photographs and of the author's pyranometer observations will be given fully in the "Smithsonian Miscellaneous Collections." W. W. B.

686. *Cape Observations of Sun, Mercury, and Venus.* (Nature, 105. p. 183, April 8, 1920.)—This is an abstract from Cape Annals, Vol. VIII, Part IV, pp. 1D–93D, which has just been distributed. The observations were made with the new transit circle and travelling-wire micrometer in the 5 years 1907–1911. Equinox corrections from the three bodies are in good accord. Corrections are given to the longitudes of perihelion of Mercury, Venus, and the Earth, and it is shown that Asaph Hall's modification of Newton's Law, adopted by the Nautical Almanac, gives values further off from Newton's than the Einstein hypothesis does. The results for diameters of Mercury and Venus are larger than the tabular ones, but the latter may be too small as they depend considerably on observations during transits, while the Cape results may be too large on account of irradiation. W. W. B.

687. *Tidal Friction and Secular Acceleration of the Moon.* **G. I. Taylor.** (Roy. Astron. Soc., M.N. 80. pp. 308–309, Jan., 1920.)—By two separate methods [see Abs. 311 (1920)] the author obtains values for the mean rate of dissipation of energy by tidal currents in the Irish Sea. One gives $2 \cdot 5 \times 10^{17}$ ergs per sec. and the other is only 20 % greater. Taking H. Jeffreys' estimate [see next Abs.] for the rate of dissipation of energy required to produce the secular acceleration of the moon (9 seconds per century per century), it appears that the Irish Sea contributes $\frac{1}{55}$ of this. The author points out that the large oceans contribute practically nothing as the tidal currents are only important in small areas close to the shore. He therefore concludes that there are probably sufficient suitable regions like the Irish Sea to provide all the dissipation required. W. W. B.

688. *Chief Cause of Lunar Secular Acceleration.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 80. pp. 309–317, Jan., 1920.)—Tidal friction is generally quoted as the cause of that part of the lunar secular acceleration not explained by gravitation. In the body of the earth it is of two possible types, according to whether the imperfection of elasticity which causes it is due to the incompleteness of the recovery of the strain, or merely to its slowness. Having regard to latitude variation and to the motion of seismic waves the author argues that this fails to account satisfactorily for the dissipation of energy required. He also rules out the atmospheric tide, both gravitational and thermal. He considers Taylor's suggestion [see preceding Abs.] to be the first true cause capable of producing sufficient effect. He discusses the possibilities of other areas than the Irish Sea, and shows that the effect of such tidal friction is inappreciable on latitude variation and earthquake waves. He gives a mathematical computation of the dissipation of energy, which is, however, only approximate, discussing the reason of the discrepancies between theoretical and observed values of the secular acceleration of the sun; and of the discordance between the theoretical and observed ratio of the spring and neap tides, which he attributes to the greater influence of friction in reducing the tide when its velocity is greatest. W. W. B.

689. *A Nova in a Spiral Nebula.* **M. Wolf.** (Astron. Nachr. No. 5038. Nature, 105. p. 213, April 15, 1920. Abstract.)—The S-shaped faint spiral nebula N.G.C. 2608 was photographed on Feb. 8 and a nova was discovered near the left-hand point of the upper curve. It was found faintly showing on plates taken Jan. 25 and Feb. 7, but not in previous years. Visually it appeared brighter on Feb. 11 than on Feb. 12, when its photographic magnitude was 10·7. Its magnitude on March 10 was observed as 11·5. It is important to obtain good light-curves of these novæ in spirals in order to get a clue to the absolute magnitude of the star and hence the distance of the spiral, so there is a sketch map given in the Astron. Nachr. to encourage observations during the two months in which they are possible. W. W. B.

690. *Observations of Wolf's Periodic Comet.* **E. E. Barnard.** (Astron. J. 32. pp. 145–149, Jan. 26, 1920.)—For the second time the author discovered this comet independently, to learn afterwards that he had been anticipated in Europe by two days. The first occasion was in 1891. A complete set of measures is given from 1918, July 11 at intervals till 1919 April 1. Most of the time the comet branched out into a fan-shaped small tail with a faint nucleus eccentrically placed in the nebulosity. Several small nebulæ were seen with the comet, and positions of three are given. W. W. B.

691. *New Form of the Law of Planetary Distances.* **E. Belot.** (Comptes Rendus, 170. pp. 579–582, March 8, 1920.)—The author is concerned with his theory of the spiral formation of the planetary and satellite systems and considers that this, as well as the cause of their rotation, should be clearly shown in the law of distances. He objects to empirical laws, which, he says, ignore the restrictions of physical reality and of celestial mechanics. His own law, $X_n = 62 + 1{\cdot}886^n$, the unit being a "solar radius," satisfies Laplace's criterion. Similarly his law for Jupiter's satellites satisfies the relation between the mean motions of the inner satellites. He sketches a spiral cosmogony indicating the process of successive condensations, and accounts for its selective action. Moreover he differentiates between the behaviour of the light planets Jupiter, Saturn, and Uranus, in the resisting nebular medium, and that of the denser planets. The wisps of spiral have disappeared by condensation into planets in the solar system, but in the spiral nebulæ they are still visible. The only difference is, he claims, in the time element, the evolution of the nebulæ being very slow. He predicts that they will ultimately condense into systems like the solar system. W. W. B.

692. *Suggested Decrease of Period of Certain Variables* **H. H. Turner.** (Roy. Astron. Soc., M.N. 80. pp. 273–289, Jan., 1920.)—The author finds evidence that some stars in Phillips' Group II show a progressive decrease of period, the decrease coming in steps at commensurable but not equal intervals. Starting with R Hydræ for instance he finds that at regular intervals of 3415 days the period is *liable* to diminish by 10 days, but does not always do so. He finds eleven such jumps since the variability was discovered in 1672, bringing the period down from 518 to 408 days. Search for similar data for other stars has produced S Tauri, U Herculis, R Aquilæ, χ Cygni, S Cygni, and S Coronæ Borealis; which are also discussed in the present paper. The conclusion is drawn that possibly all stars of the Phillips' Group II show this tendency to decreasing period. Group I stars will be dealt with afterwards, but the author thinks their periods are increasing. W. W. B.

693. *Bright Nebulæ and Star Clusters in Sagittarius and Scutum.* **J. C. Duncan.** (Mt. Wilson Observat., Contrib. No. 177. Astrophys. J. 51. pp. 4–12, Jan., 1920.)—Five plates of photographs taken with the 60-in. reflector, including, in Sagittarius, Nebulæ N.G.C. 6523, Cluster N.G.C. 6530, and Globular Cluster N.G.C. 6656; and in Scutum, Cluster and Nebula N.G.C. 6611, and Swan Nebula N.G.C. 6618. The first two of these form Messier 8, and the others are respectively M. 22, M. 16, and M. 17. Previous observations are mentioned. This is the first published large-scale photograph of M. 22, the plate showing about 75,000 stars, one-third of them cluster stars by Shapley's estimation; each of the three nebulæ shows dark markings. A spectrogram of M.16 by Slipher, shows Nb lines weaker than H, indicating a small radial velocity. A correction is given to the catalogue place of one of the comparison stars, Cordoba, 12431. The cluster M. 22 is at an estimated distance of 27,000 light-years and is nearer the galactic plane than any other known cluster. W. W. B.

694. *Problem of Cepheid Variables.* **J. G. Hagen.** (Astrophys. J. 51. pp. 62–64, Jan., 1920.)—This is a contribution to the controversy between supporters of the rival theories "binary" and "pulsation," of which the author is inclined to the former, his theory attributing the variation to satellite action. If this be true he would expect to find binaries with a very slight variation, as well as those which vary a whole magnitude. These, however, would not be so likely to be discovered. A recent list of 18 stars with common properties given by Adams and Joy is suggested for careful study. These have spectral types between F and K. Their angular P.M.'s are less than 0·040″, except one which is 0·100″. They are all but two within 26° of the galactic plane, and their absolute magnitudes appear to range between —1 and —4. The author thinks these ought to supply material of great value towards deciding between the rival theories. W. W. B.

695. 70 *Ophiuchi* (Σ 2272) *and Neighbouring Stars.* **G. C. Comstock.** (Astron. J. 32. pp. 153–159, Feb. 7, 1920.)—Eight nearly independent determinations of mass ratio of the components of 70 Ophiuchi, adopting the parallax of 80·18″, periodic time 87·5 years and major axis 4·5″, yield the result that the combined mass of the binary is 2·04 times that the sun, the components having respectively masses of 1·14 and 0·90. The three faint stars near 70 Ophiuchi, noted by Asaph Hall, were also investigated and two of them, of 13th magnitude, are found to have proper motions of about 3″ per century. The relative results of comparing the principal star with these three " background " stars are so discordant as to negative the suggestion that all the motion is due to 70 Ophiuchi, so that the author is satisfied of the reality of the proper motions of the two faint stars. W. W. B.

696. *Faint Nebulæ.* **E. P. Hubble.** (Yerkes Obs. Publ. 4. Part 2. Nature, 105. p. 84, March 18, 1920. Abstract.)—Photographs of rich nebulous regions, including seven well-defined clusters, and containing more than 500 nebulæ, were taken with the 24-in. reflector at Yerkes Observatory. The outer parts of the field were not well defined, so that the position measures are lacking in precision. Exposures mostly did not exceed two hours. Average diameter of nebulæ 25″, but in some regions only 15″. The author's discussion of the parallaxes is inconclusive on the question whether these faint nebulæ are on the confines of the galactic system or beyond it. W. W. B.

697. *Parallax of Capella and its Distant Companion.* **Z. Daniel** and **F. Schlesinger.** (Astron. J. 32. pp. 163–164, March 6, 1920.)—Fifteen plates taken between Feb. 1915 and Feb. 1919, at Allegheny Observatory, yield for Capella a relative parallax of + 0·049″ ± 0·007″, and for the distant companion, discovered by Furuhjelm, about 12′ away from Capella, + 0·079″ ± 0·008″. The comparison stars were not considered quite near enough and a second solution from one close star only gave for the companion + 0·067″ ± 0·009″. The adopted mean on the assumption that the stars have the same parallax is + 0·063″ ± 0·006″, and allowing 0·005″ for the parallax of the comparison stars, the absolute parallax is + 0·068″. W. W. B.

698. *Parallaxes of Globular Clusters and Spiral Nebulæ.* **K. Lundmark.** (Kungl. Svenska Vetenskapsakad. Handlingar, Vol. 60. No. 8. Nature, 105. p. 215, April 15, 1920. Abstract.)—Charlier having doubted the correctness of the enormous distances announced by Shapley, the author re-examined the question. In the matter of clusters, he finds : (1) from known proper motions, with Slipher's value for mean radial velocity, 3000 parsecs (Shapley's value about 15,000) ; (2) from Kapteyn's luminosity law applied to M. 3 and M. 13, mean of several independent determinations, 6000 parsecs ; (3) rough estimate from observed mean absolute magnitudes of stars of different spectral types, about 5000 parsecs ; (4) regarding clusters as single objects of the same absolute magnitude, relative distances of clusters are proportional to Shapley's, whose values are in all four ways shown to be far nearer the probable truth than Charlier's, which give distances about 250 times smaller. The author uses Slipher's radial velocities to determine the sun's motion relative to clusters, and finds a value for the velocity of 381 km./sec. towards R.A. 320° N. decl. 74°. Both R.A. and Decl. tend to increase as fainter stars are used, which he explains to be due to a larger proportion of the stars being outside the local cluster.

For the spiral nebulæ. (1) Mean of discordant measures of parallax of Andromeda nebula is near zero. (2) Star density increases towards the middle of the Andromeda nebula, hence the nebula is probably more distant than the independent faint stars. A mean result gives 3000 parsecs for these stars. (3) Measured angular rotation combined with spectroscopic linear rotation point to larger distance, say 4000 parsecs. Mass necessary to control is given as 1000 million times that of the sun. (4) Wolf makes an assumption about the dark spaces in nebulæ which gives distances for different spirals ranging from 10,000 to 200,000 parsecs (5) Comparing light-curves of novæ in spirals with those in the galaxy, gives large values for the distances of nebulæ, 200,000 parsecs for the Andromeda nebula, whose brightness, noted by Bullialdus in 1664, is attributed to a 5th or 6th magnitude nova appearing in it. These considerations induce the author to support Shapley's large values, placing the spiral nebulæ far beyond the galactic limits. He thinks that they are not counterparts of the galaxy, being very much smaller, but that they are the star-producing mechanisms of Jeans's theory. W. W. B.

699. *Colours and Magnitudes in Stellar Clusters.* XV. *Photometric Analysis of Globular System, M.* 68. **H. Shapley.** (Mt. Wilson Observat. Contrib. No. 175. Astrophys. J. 51. pp. 49–61, Jan., 1920.)—This is based on 15 photographs taken at the primary focus of the 60-in. reflector. Twenty-eight variables were discovered, with one exception typical cluster short-period variables. Only 250 stars in the cluster are brighter than zero absolute magnitude, in contrast to most clusters; 56 of the brightest are tabulated in colour and magnitude, mostly red or yellow. These methods agree in yielding a distance of about 55,000 light-years. Taking the 2000 brightest stars the form of the cluster is accurately circular.

The analysis supports the general conclusions in regard to clusters. (1) Cluster type variables are bluer at maximum. (2) Their mean brightness seems to be an astrophysical constant, about one magnitude fainter than the mean brightness of the 25 brightest stars in the cluster. (3) Of the giant stars, the fainter are the bluer on the average. (4) The brightest "giants" are always very red, absolute photo-visual magnitude between −4 and −3. (5) The general luminosity curve for the stars of the cluster is very different from a symmetrical probability curve. (6) The distance can be computed in three ways: (*a*) from the diameter of the image of the clusters, (*b*) from the mean magnitude of the 25 brightest stars, or (*c*) from that of the short-period variables. W. W. B.

700. *Infra-Red Spectra of Nebulæ.* **W. H. Wright.** (Astron. Soc. of the Pacific, Publ. No. 185. Nature, 105. p. 149, April 1, 1920. Abstract.)—Using special plates sensitive to the infra-red, and a single-prism spectrograph in conjunction with the 36-in. Lick refractor, photographs were taken of the spectrum of N.G.C. 7027 (planetary). Lines previously found include λ6678 and λ6730, while four lines in the extreme red are claimed as new, approximate wave-lengths 7009, 7065, 7138, and 7325. Fair definition was obtained in the region 6700 to 8500, though the focus was not good for that region. W. W. B.

701. *Einstein Effect and Displacement of Solar Lines.* **C. E. St. John.** (Observatory, 43. No. 551. pp. 158–162, April, 1920.)—The author accepts the evidence afforded by the 1919 eclipse plates of the Einstein prediction in regard to the deflection of light, but after a critical discussion of results from cyanogen bands, concludes that in regard to the prediction of spectral shift the evidence is on the whole against Einstein, and will not be surprised to find the Newtonian law confirmed. The difficulty of reconciling collateral evidence from different substances he attributes to the probability that they originate in different layers of the solar envelope. He emphasises the special precautions necessary in pursuing the investigation, especially with the cyanogen bands, and gives his most recent measures derived from Fe lines in the blue and from the Mg triplet in the green, both being distinctly smaller than Einstein's value. W. W. B.

702. *On Parallaxes and Proper-Motions of the Two Faint Stars, B.D. + 8°·3689 and 3692.* **F. Schlesinger.** (Astron. J. 32. pp. 173–174, March 11, 1920.)—From Allegheny measures taken in conjunction with previous determinations a parallax of + 0·036″ ± 0·005″ (absolute) is derived, on the assumption that the stars have the same parallax. Their proper-motion is probably the same, amounting to 0·51″ in position angle 203°. They must form a system in which though physically connected the stars are very distant from each other. From the adopted parallax the distance between them must be 17,000 times that between the earth and the sun and may be much greater still unless they are nearly in apparent quadrature. If the combined mass is equal to the sun the period of revolution must exceed two million years. W. W. B.

LIGHT.

703. *Equatorial Mounting for Eclipse Observations.* **C. Davidson** and **W. V. Woodman.** (Roy. Astron. Soc., M.N. 80. pp. 318–319, Jan., 1920).—The delicacy of the test of Einstein's theory afforded by a solar eclipse renders it very important to increase the precision obtained. The cœlostat used at the last eclipse is open to objection from this point of view, and the authors propose next time to dispense with the cœlostat and use an equatorially mounted telescope. The object in view is to provide a sufficiently rigid support, so constructed that it can be erected without difficulty at a station where skilled labour is not obtainable. Details are given of the way in which the tube and polar axis are divided into sections to be bolted together on the spot. Skeleton piers of angle iron are proposed to be made solid by filling in with earth or concrete after erection. These must be constructed for the latitude required. The eclipse station the authors have in view is Christmas Island in Lat. 11° S. Dimensions of the completed instrument are given and a working programme for the actual mounting and adjustment. W. W. B.

704. *Diaphragms for Microscopic Vision.* **R. A. Occhialini.** (Riv. Ottica e Meccan. 1. pp. 43–47, Nov.–Dec., 1919.)—Considers, both from the theoretical and the practical point of view, the advantage in definition to be obtained by the use of a diaphragm of suitable size, when viewing very fine detail. J. W. T. W.

705. *Relation between Incident Angle and Deviation produced by a Prism.* **T. Smith.** (Optical Soc., Trans. 21. No. 1. pp. 49–50, 1919–20.)—For a prism of known refractive index μ and angle a, the angle of incidence corresponding to an angle of deviation δ is given by the equation

$$\cos\varphi\left\{\cos a-\cos(a+\delta)\right\}=\mu^2\sin^2 a+\cos a\cos(a+\delta)-1,$$

where the angle of incidence is $\frac{1}{2}(a+\delta+\varphi)$. A form of equation for logarithmic calculation is given in the paper. J. W. T. W.

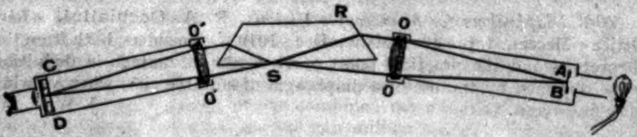
706. *Geometrical Construction for the Refracted Ray.* **G. Astorri.** (Riv. Ottica e Meccan. 1. pp. 13–15, Sept.–Oct., 1919.)—Gives details of a method for the geometrical construction of the refracted ray, and applies the method to the case of a Ramsden eyepiece. J. W. T. W.

707. *Three-Lens Cemented Aplanatic Objective.* **T. Kondo.** (Phys. Math. Soc., Japan, Proc. 2. pp. 27–30, Feb., 1920.)—Describes the method of calculation of the three-lens cemented objective of general design. J. W. T. W.

708. *Geometrical Optics of Aperture in a System of Lenses.* **A. Hnatek.** (Zeits. Instrumentenk. 39. pp. 341–350, Dec., 1919.)—In the consideration of a system of lenses it is desirable to ensure, on the one hand, that no lens is so small as to introduce a stop restricting unnecessarily the aperture of the system and, on the other hand, that the lenses used are not unnecessarily large in diameter. The author treats the geometrical optics of a system of lenses and shows how it is possible to determine the necessary size of any particular lens in a given system. He does this for certain systems to illustrate the method. J. W. T. W.

709. *Grating Spectra with Oblique Incident Light.* **S. Procopiu.** (Comptes Rendus, 170. pp. 388–390, Feb. 16, 1920.)—If a grating is set up to give spectra in the ordinary way, and is then rotated about an axis in the plane of the grating and perpendicular to the lines, the limiting edges of the spectra become curved and apparently approximate to parabolas. These curves have been photographed, and it is found that the spacing of the apexes of the curves remains the same as that of the original straight lines of the spectra formed by the grating in its original position. The curves are nearly parabolic in shape, and an empirical formula is suggested for the equation of these curves in terms of the angle of inclination of the grating. J. W. T. W.

710. *Measurement of Prism Angle.* **T. Collodi.** (Riv. Ottica e Meccan. 1. pp. 23–25, Sept.–Oct., 1919.)—Describes a method for the rapid and simple measurement of the angle of a prism. In the fig., O R and O S are two parallel rays. O S is reflected from the base of the prism, O R is refracted at the first face, reflected at the base, and then refracted out of the prism again. The small angle between the emergent rays O′S can be measured by the horizontal and vertical distances between the images at C D. Thus the angle of the prism and the difference between the verticality of the two faces can be deduced. J. W. T. W.



711. *Fizeau-Effect in Solid Substances.* I. **P. Zeeman.** (K. Akad. Amsterdam, Proc. 22. 5. pp. 462–470, 1920.)—This paper describes the apparatus used for the investigation of the motion of light in solid substances. The moving transparent substance (glass or quartz) is rigidly connected to a slide which by a link mechanism is caused to move backwards and forwards about 184 times per min., the max. velocity being a little more than 10 m. per sec. It was found possible to obtain pure interference lines, and these were photographed first with the substance moving in one direction, and secondly when moving in the opposite direction. These photographs were obtained by admitting light during a time of the order of 0·01 sec. and at the moment of max. velocity. For this time interval the velocity is very nearly constant. To get a good impression, 20 or 30 successive images were superposed. The optical effect to be expected, when l represents the length of the moving transparent substance, is $\frac{4l}{\lambda . c}(1/\mu - 1/\mu^2 - \lambda/\mu^2 . d\mu/d\lambda)\,\mu^2 w$, w being the velocity of the substance and c the velocity of light *in vacuo*. It appears from this formula that the optical effect is approximately proportional to $(\mu - 1)$. Further details will be given later. [See Abs. 1340 (1916).] A. W.

712. *Fizeau-Effect in Solid Substances.* **P. Zeeman** and **[Miss] A. Snethlage.** (K. Akad. Amsterdam, Proc. 22. No. 6. pp. 512–522, 1920.)—In a previous paper [see preceding Abstract] a description was given of apparatus adapted for the study of the Fizeau-effect in solid substances. The present paper describes measurements carried out with the apparatus on quartz. Ten quartz rods were used in the first set of experiments and fourteen in the second set, giving columns respectively of lengths 100 cm. and 140 cm. Measurements were made for wave-lengths λ 4750, λ 5380, and λ 6510, and the corresponding displacements of the interference bands observed were 0·156, 0·148, and 0·124, as against values 0·166, 0·143, and 0·115 calculated from Kohlrausch's data for the index of refraction of the ordinary ray in quartz. Two derivations of the theoretical formula are given, the latter of these being based on the theory of relativity. A subsequent paper will deal with the Fizeau-effect in glass. A. W.

713. *Colorimetry of Nearly-White Surfaces.* **A. H. Pfund.** (Frank. Inst., J. 189. pp. 371–379, March, 1920.)—The present paper deals with surfaces of great brightness and small departure from white. In order to accentuate this departure, the method of multiple reflections was applied. Taking advantage of the fact that multiple reflections from similar surfaces accentuate selective reflection, a new colorimeter, adapted to the study of nearly-white surfaces, has been developed. Light from a Mazda C 100-watt lamp illuminates the outer portion of a circular disc A whose upper surface is covered with the material to be studied. The light, diffusely reflected, illuminates the lower (coated) surface of a second disc B of ring shape, located above the first, and the disc B, in turn, illumines the centre of A. The light after multiple reflections, passes upwards through the opening in B, and is reflected horizontally by means of a photometer cube. Another beam of light, diffusely reflected from a plate of optical glass, roughly ground on both sides, is used as a comparison beam and fills the upper half of the field of view of the photometer cube. By rotating the glass plate, the intensity of the reflected beam of white light may be varied at will. Using this apparatus, it has been found that our usual standards of "white" ($MgCO_3$ and MgO) depart noticeably from the ideal. $MgCO_3$ is definitely yellowish, while MgO is bluish for thin layers and yellowish for thick layers. A. W.

714. *The Dye Impression Printing Process.* **F. W. Donisthorpe.** (Phot. J. 60. pp. 119–120, March, 1920.)—The principle of the process is that a negative is made on an ordinary dry-plate emulsion, which may have either an opaque or transparent support, and prints are made, not by exposing through the negative, but by taking contact impressions from the negative without any action of light. For this purpose, by a simple operation, the negative is converted into a state in which it can be treated in a dye-bath, and after dyeing prints are taken from it by the application of gelatine-coated paper. About one minute's contact suffices to produce the impression. A short account of the process is given. It is claimed that, to the amateur, this process has the advantage of cheapness; for the sensitive material for exposure in the camera need only be emulsion-

coated paper, and for the prints, the paper being in no way sensitive to light, costs from one-fourth to one-tenth the price of bromide paper, while the dye-bath represents only an infinitesimal cost per print. In professionalism the process is likely to have wide applications to commercial reproductions and enlargements and to the reproduction of line work such as maps, plans, and documents. During the *discussion* the **Author** stated that the pictures so obtained could be put in brilliant sunshine for six months without any apparent change. He had not up to the present worked out the system for three-colour work. The best way of proceeding to transfer and register is debatable. An indefinite number of prints can be taken from the same negative. It is usual to resort to the dye-bath every time between printing, but it is possible to dye up strongly and pull off six prints right away, though this sometimes leads to an effect of double toning. It is possible to produce matt prints, but not very rough ones. The process is in no way dependent upon the tanning of the gelatine, which remains absolutely soft on this process. The darkest parts of the silver image wax is covered over with a fine pigment so finely divided that the dye solution will not penetrate into the interstices, and if the pigment is removed the image is exactly as before. Instead of tanning the gelatine, the image is waterproofed in various degrees. A. E. G.

715. *Action of Coal on a Photographic Plate.* **E. Sinkinson.** (Chem. Soc. J., Trans. 117. pp. 165–170, March, 1920.)—This communication is the outcome of an attempt to discover what constituent of coal substance is responsible for its well-known action on a photographic plate in the dark. This action depends on the presence of oxygen. Thus, if a piece of coal is placed on a photographic plate in a light-tight box and all the air displaced by nitrogen, no action will result. Further, a small quantity of water-vapour will prevent any action, even in the presence of air. Moreover, if the box is exhausted, no image can be obtained.

The author describes a careful examination of this effect in the cases of a variety of samples of coal and coal constituents, before and after heat treatment at different temperatures. He concludes as a result of such investigation, that the ingredient causing the action on the photographic plate is localised in the pyridine extract; and the remaining constituents of this extract, other than resin, are probably responsible for the effect. A. B. W.

716. *Examination of Ores and Metals in Polarised Light.* **F. E. Wright.** (Am. Inst. Mining Eng., Bull. No. 158 [12 pp.], Feb., 1920.)—A description is given of several methods available for the determination of the degree of anisotropism of a plate of an opaque substance when examined in normally reflected light. (*a*) The plate may be illuminated by natural incident light, in which case anisotropism is recognised by a difference in the intensity of the reflected components of the light. Koenigsberger's method is described under this head and also the author's modification in which either a single calcite cleavage plate with proper aperture or a small Koeing-Martens photometer is used. It is claimed that this modification is simpler in adjustment and in manipulation. (*b*) The plate may also be illuminated by plane-polarised, incident light, anisotropism being recognised by a rotation of the plane of polarisation of incident, plane-polarised waves after reflection. Under this head, Koenigsberger's and

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Hanemann's methods are described and also a modification by the author consisting of the substitution of a bi-quartz wedge plate for the Biot plate of Koenigsberger or the Biot-Soleil plate of Hanemann. In opaque substances, the precision attainable is relatively small and the phenomena which can be observed are few and restricted in scope. As a result of this less must be expected from the examination by means of polarised light than has been the case with transparent crystals. C. O. B.

717. *Excitation of the Spectra of Carbon, Titanium, and Vanadium by Thermoelectronic Currents.* **G. A. Hemsalech.** (Phil. Mag. 39. pp. 241–285, March, 1920.)—This paper gives an amplified account of experiments previously mentioned [Abs. 253 (1920)]. The observed phenomena are described in detail; tables are given of the wave-lengths of the lines observed, and data presented to show that the emission from the luminous vapour is of precisely the same type as that observed in a carbon-tube resistance furnace. The results are discussed at some length, special reference being made to King's results with an electric furnace. Typical photographs are reproduced. A. W.

718. *Critical Electron Velocities for Argon.* **F. Horton** and **[Miss] A. C. Davies.** (Roy. Soc., Proc. 97. pp. 1–23, March 1, 1920.)—The authors have previously given an account of an investigation of the effects of electron collisions with helium atoms [Abs. 781 (1919)]. The apparatus and method have been somewhat modified, and applied to a similar investigation with argon. The experiments show that when electrons bombard argon atoms, a radiation is first produced from the gas when the electrons attain a velocity of 11·5 volts, and that ionisation of the gas occurs when the electron velocity is further raised to 15·1 volts. From the quantum relation $eV = hn$, taking $e = 4\cdot77 \times 10^{-10}$ e.s. unit and $h = 6\cdot55 \times 10^{-27}$ gm. cm.^2/sec. the limiting frequency in the argon spectrum is found to be $n = 3\cdot67 \times 10^{15}$, corresponding to a wave-length of 817 Å.U. This agrees with Lyman's results, for he found the argon spectrum to terminate abruptly near λ 800. A certain amount of evidence has been obtained that, when the electron velocity is greater than the critical ionising value, the fraction of the total number of collisions which result in ionisation is greatly increased by the presence of intense 11·5-volt radiation, but no detectable amount of ionisation is produced below 15·1 volts whether the radiation is weak or intense. [See Abs. 659 (1913).] A. W.

719. *Effects of Electron Collisions with Platinum and with Hydrogen.* **F. Horton** and **[Miss] A. C. Davies.** (Roy. Soc., Proc. 97. pp. 23–43, March 1, 1920.)—*Platinum.* The experiments described were carried out with the object of ascertaining whether the production of ionisation from platinum is due to occluded hydrogen or to the metal itself. In the course of an investigation of the effects of electron collisions with helium atoms [Abs. 781 (1919)] it was found that positive ions were produced from a positively-charged platinum gauze when this was bombarded by electrons with a minimum velocity of about 11 volts. The results of the present experiments show that reflection of slow-moving kathode rays at a negatively-charged platinum surface takes place for small velocities of the electron stream, and that secondary rays, with a velocity of emission of about 10 volts, are excited with higher velocities of the electron stream, though no exact observations have been made. It has been found that the excitation of secondary rays is a genuine ionisation effect, and that it begins at a minimum electron velocity of 13·0 volts. No sign of the production of a radiation capable of acting photoelectrically on platinum was detected in the special experiments made to investigate this. By admitting hydrogen into the apparatus it was proved that the ionisation which begins at 13·0 volts is not due to hydrogen attached to the platinum surface, and is therefore probably produced from the metal itself.

Hydrogen.—Investigation of the effects of electron collisions with hydrogen has shown: (i) That a radiation is produced at a minimum electron velocity of 10·5 volts. (ii) That a second type of radiation is produced, beginning when the electron velocity reaches 13·9 volts. (iii) That ionisation of the gas occurs at a minimum electron velocity of 14·4 volts. (iv) That a second type of ionisation begins when the electron velocity reaches 16·9 volts. A comparison of these results with those deduced from Bohr's theory is given in the following table:—

	Critical Electron Velocities (Volts).				
	Radiation from the Atom.	Ionisation of the Atom.	Radiation from the Molecule.	Ionisation of the Molecule.	Dissociation of the Molecule.
Calculated from Bohr's theory	10·2	13·6	—	16·3	2·7
Determined experimentally	10·5	14·4	13·9	16·9	2·5

The theoretical value of the ionisation potential for the molecule is calculated on the view that the ionisation results in the production of an electron, a positive nucleus, and a neutral atom. The experimental values are all rather higher than the calculated values, but the velocity distribution curves obtained in these experiments showed that only a small percentage of the total number of electrons in the bombarding stream has the max. velocity, so that a correction should probably be applied to the values given. A. W.

720. *Displacement of Spectral Lines and Equivalence Hypothesis.* **W. G. Duffield.** (Roy. Astron. Soc., M.N. 80. pp. 262–272, Jan., 1920.)—In view of the comparative failure of the careful experiments of Evershed and St. John [see Abs. 247 (1918)] to find the displacement of solar spectrum lines, required to satisfy Einstein's third test, the author discusses the known causes which can produce spectrum shifts, including pressure, anomalous dispersion, arc conditions, magnetic effects, etc. The cyanogen bands are, he says, generally relied upon as being not displaced by pressure; but he claims that they are certainly affected by pressure, and is sceptical as to their absolutely invariable wave-length. He thinks surface currents in the sun may interfere with the refined measurements necessary. Evershed's more recent figures pointed to an effect from ⅓ to ¾ of that predicted by Einstein. Still more recently Grebe and Bachem claim to have discovered dissymmetry in individual members of the cyanogen band, and deduce a displacement of 82 % of Einstein's figure

V.2
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[Abs. 1504 (1919)]. The author considers that surface currents would prevent the evidence from being conclusive, however, even if the full Einstein displacement were indicated. W. W. B.

721. *Constitution of the Elements.* **F. W. Aston.** (Nature, 105. p. 8, March 4, 1920.)—Several more elements have now been subjected to analysis, yielding interesting "mass-spectra" [Abs. 265 (1920)]. Argon (atomic weight 39·88 Ramsay, 39·91 Leduc) gives a very strong line exactly at 40, with double charge at 20 and triple charge at 13½. The last line, being closely bracketed by known reference lines at 13 and 14, provides very trustworthy values. There is also an associated faint line at 36. This has not yet been proved an element by double and triple charges, but it is very probable that this line is a true isotope, the presence of which to the extent of 3 % is enough to account for the fractional atomic weights quoted. *Helium* was compared with O + + (8) by a special system of bracketing, and directly with C + + (6) by extrapolation. Both methods give its mass as 4, with an accuracy of 2 or 3 parts in 1000. *Hydrogen.*—By the same methods H_3, H_2, and H_1 all give consistent results for the mass of the hydrogen atom as 1·008 within experimental error. These three lines are the only ones diverging from the whole number rule to a definite and measurable extent. *Nitrogen* is apparently a "pure" element, its doubly charged atom being 7 exactly.

Krypton (atomic weight 82·92) has no fewer than six constituents: 78, 80, 82, 83, 84, and 86. The last 5 are strong lines confirmed by double- and triple-charged clusters, which can be compared with great accuracy against A (40) and CO (28). These reference lines obliterate one of each group, but not the same one. The 78 line has not yet been confirmed in this way owing to its faintness. Krypton is the first element giving unmistakable isotopes differing by one unit only.

Rough provisional values for *xenon* may be taken as 128, 130, 131, 133, and 135. Further examination of the multiply-charged *mercury* clusters indicates the probability of a strong line at 202, a weak component at 204, and a strong band including 197 and 200, unresolvable up to the present. A. W.

722. *Continuous Spectrum of X-Rays.* **L. Brillouin.** (Comptes Rendus, 170. pp. 274–276, Feb. 2, 1920.)—It is well known that X-ray tubes give two kinds of spectrum, a line spectrum and a continuous spectrum. The theory of line spectra has been developed by Sommerfeld as a generalisation of Bohr's theory. From a theoretical standpoint, however, comparatively little attention has been paid to continuous X-ray spectra. The theory of quanta has indicated the limiting wave-length λ_l of the continuous spectrum, given by the relation $Ve = hc/\lambda_l$, where V is the potential applied to the X-ray tube, e the electronic charge, h is Planck's constant, and c the velocity of light. Experiment has verified this law and has given curves showing how the intensity I_λ varies with the wave-length λ in the continuous spectrum.

In the present paper the author obtains theoretical indications relating to these curves. A. B. W.

723. *Series in the Spectrum of Barium.* **F. A. Saunders.** (Astrophys. J. 51. pp. 23–36, Jan., 1920.)—The spectrum of barium contains three systems of series, the triplets, the single lines, and the pairs. After making

a careful study of all available data, including recent unpublished observations by King, the author has revised and extended the previously recognised series of triplets and single lines, and has identified the lines corresponding to one or more terms of each of several other series. Altogether about 135 lines are assigned to one or other of sixteen series, which include six series of triplets, eight series of single lines, and two inter-system combination series. Accurate constants for these series are given. The fundamental and diffuse series of triplets are unusually complex, and these and other series show curious irregularities both in the relative intensities of the terms and in the wave-lengths. No simple formula of the ordinary type will give the frequencies accurately. The paper includes a brief explanation of the notation used in designating the different series.
A. W.

724. *Intensities of X-Rays of the L-Series.* II. *Critical Potentials of the Platinum Lines.* **D. L. Webster.** (Nat. Acad. Sci., Proc. 6. pp. 26–35, Jan., 1920.)—The work described is a continuation of that of Webster and Clark [see Abs. 507 (1917)]. The object in view was to investigate the laws relating intensity to potential, for the L-series lines, for the purpose of comparison with current theories of X-ray spectra, and the present paper deals with the determination of the critical potentials of the platinum lines of medium intensity, the stronger ones having been reported in the previous paper and the fainter ones, observed only in tungsten by Dershem and Overn, being so faint as to require a much more prolonged study.

The paper contains a detailed description of the apparatus used, with full particulars of the lines of medium intensity observed in the L-series for platinum.
A. B. W.

725. *Rings of Connecting-Electrons in Bragg's Model of the Diamond Crystal.* **D. Coster.** (K. Akad. Amsterdam, Proc. 22. No. 6. pp. 536–541, 1920.)—A mathematical paper dealing with the work of Bragg, Bohr, and Debye and Scherrer with reference to this subject.
A. B. W.

726. *Determination of Parameters of a Crystal by X-Rays.* **F. Canac.** (Comptes Rendus, 170. pp. 394–396, Feb. 17, 1920.)—In an earlier paper the author has demonstrated the advantage in reflecting power to be gained by reflecting X-rays from the reticular planes passing through the axes of symmetry of the crystal, these planes being richest in atoms [see Abs. 672 (1920)]. Two methods are now described for determining the parameters of a crystal. Experimental observations in the case of a cubic crystal of sugar give results in good agreement with the optical measurements of Wolff (Journ. f. prakt. Chemie. 28. p. 129, 1843).
A. B. W.

HEAT.

727. *An Interferential Dilatometer.* **I. G. Priest.** (Bureau of Standards, Bull. 15. pp. 669–678 [Sci. Papers, No. 365], 1920.)—The substance whose thermal expansibility is required is used as a pillar to support a glass plate. The other side of the plate is supported by some standard substance, such as glass, quartz, or metal, of known expansibility. When temperature rises there is a differential expansion between the pillar and the standard substance. This expansion produces a movement of the interference fringes formed in the usual way between the glass plate and the surface of the standard. The peculiarity of the present method lies in the fact that the *distance* between the interference lines and not the *number* of lines *passing* a spot, is measured.

Advantages.—Several advantages are claimed for this development of Fizeau's method, namely: (1) Only one small sample is required instead of three, as in the usual method; (2) there is no necessity to evacuate the apparatus to correct for change in refractive index of the air; (3) elimination of the trouble of counting the number of rings passing a point. P. E. S.

728. *Gouy Thermo-regulator.* **T. S. Sligh, Jr.** (Am. Chem. Soc., J. 42. pp. 60–68, Jan., 1920.)—Describes experiments to determine the improvement produced in the closeness of regulation of an ordinary thermoregulator (which depends on the opening and closing of a contact between a Pt point and a mercury meniscus) by giving the platinum wire an oscillatory movement of 0·3 to 3 seconds' periodicity. It was found that a large range of available energy input and consequently a large range of regulation could be obtained without sacrificing the closeness of regulation; that a bath temperature was obtained in which the periodic variations about the mean, due to operation of the regulator, were very greatly reduced; and that the temperature variations introduced by variations in the state of the mercury surface were mostly eliminated. J. W. T. W.

729. *Absolute Temperature Scale.* **F. G. Keyes.** (Am. Chem. Soc., J. 42. pp. 54–59, Jan., 1920.)—In a previous paper [see Abs. 858 (1917)] a new equation of state was proposed. Assuming that the readings of the constant-volume nitrogen thermometer lie on the absolute scale, the corrections which would follow from applying the equation of state given for atmospheric nitrogen to the constant-pressure thermometer are tabulated, and it is shown that the corrections thus obtained agree exceedingly well with those obtained by the use of the Joule-Thomson coefficients. J. W. T. W.

730. *Catathermic Phenomena.* **J. A. Le Bel.** (Comptes Rendus, 170. pp. 323–324, Feb. 9, 1920.)—Discusses various new observations, with improved experimental arrangements, on the catathermic phenomenon previously dealt with [Abs. 1079 (1918)]. A. W.

731. *Flame Propagation in Complex Gas Mixtures.* IV. *Uniform Movement and Maximum-speed Mixtures of Methane and Hydrogen in Air.* **W. Payman.** (Chem. Soc. J., Trans. 118. pp. 48–58, Jan, 1920.)—The paper [see Abs. 399 (1920)] deals chiefly with mixtures rich in oxygen. Hydrogen-oxygen mixtures correct for complete combustion contain 29·6 % H.; the speed of uniform movement is 4·8 m./sec. (in tubes 2·5 cm. in diam.), the speed of the detonation wave 1930 m./sec. (tubes 9 mm. in diam.). The max. uniform speed is obtained in mixtures with 38 % H. This displacement of the maximum-speed movement is not due to the high specific heat of H, since similar displacements are observed with other inflammable gases like CO, which have a lower specific heat than air. Considering the various factors influencing the flame propagation the author points out that the reaction velocity increases rapidly with rise of temperature and, since the combining proportion yields the highest calorific effect, the influences of mass action and of temperature-rise on the displacement oppose one another. When oxygen burns in an atmosphere (of constant composition) of nitrogen and a combustible gas, the displacement of the maximum uniform-speed mixture is towards an excess of oxygen. This is confirmed by experiments in which either methane or hydrogen is the combustible gas; the addition of either combustible gas or of oxygen to the combining proportions increases the speed of the flame. The experiments were made with mixtures of methane and air containing from 13 up to 100 % of oxygen in glass tubes, 2·5 cm. diam., only 1·5 m. long; yet the last metre of glass had to be replaced by lead piping because the detonation waves developed. In oxygen free from CH_4 the max. uniform speed was observed, as expected, with the combining proportion $CH_4 + 2O_2$, whilst the detonating wave had its greatest speed with equal proportions. In mixtures of $CH_4 + 2O_2$ the addition of methane, oxygen, or nitrogen all reduced the speed of uniform movement: methane most, nitrogen least. H. B.

732. *Heat Distribution on a Radiating Plane.* **K. Aichi.** (Phys. Math. Soc., Japan, Proc. 2. pp. 20–26, Feb., 1920.)—A continuation of previous work [see Abs. 404 (1920)] on the distribution of temperature in a radiating plane containing a known arrangement of heat sources, or an arrangement giving some defined boundary distribution. An example is given in the case of a circular boundary of given temperature. J. W. T. W.

733. *Radiation from a Cylindrical Wall.* **S. P. Owen.** (Phil. Mag. 39. pp. 359–365, March, 1920.)—Obtains an expression for the amount of flux reaching a flat plate by radiation from a cylindrical wall coaxial with the plate and with its ends at given distances from it. The problem arises in connection with experiments on the thermal conductivity of gases [see Abs. 259 (1910)], and in a second part of the paper are given the results of experiments made to obtain an approximate verification of the calculated expression. J. W. T. W.

734. *Vapour Pressure of Solid Bromine.* **T. Isnardi.** (Univ. de la Plata, Publ. [Mat. Fis. Ser.] 1. p. 419, 1916. Ann. d. Physik, 61. 3. pp. 264–272, Feb. 3, 1920.)—In the course of an investigation on the dissociation of bromine the author came to the conclusion that the data given by Ramsay and Young for the vapour pressure of solid bromine were incorrect, and that the true values should be greater. The present paper accordingly presents the results of a special investigation dealing with this problem. Previous work by Roozeboom, Ramsay and Young, and the Cuthbertsons first receives attention, this having shown that an expression of the form $\log p = ab \log T/T + c$ holds good and is derived from the Clausius equation when the specific heat is regarded as constant. Cuthbertsons' results are higher than those of Ramsay and Young. The present author has employed two different methods, full experimental details with diagrams of apparatus being given in the paper. The vapour pressure of solid bromine was found to be appreciably higher than that given by Ramsay and Young. The extrapolation of the curve up to −41·3° agrees with the extrapolated part given by the optical method of Cuthbertson. From the vapour pressure curve obtained, the coordinates of the triple point and the heat of sublimation may be calculated, the results showing satisfactory agreement with the experimental values. The vapour pressures of solid bromine for different temperatures have been calculated, tables of results being included. At 0° the measured vapour pressure lies very near to that given by Ramsay and Young, so that the value for liquid bromine given by these authors may be taken as correct.

H. H. Ho.

735. *Vapour Pressure of Ammonia.* **C. S. Cragoe, C. H. Meyers,** and **C. S. Taylor.** (Bureau of Standards, Bull. 16. pp. 1–35 [Sci. Papers, No. 369], 1920. Am. Chem. Soc., J. 42. pp. 206–229, Feb., 1920.)—These measurements form a portion of the work undertaken by the Bureau of Standards in the determination of the thermal properties of materials used as refrigerating media. The existing data on the vapour-pressure-temperature relation for ammonia are undoubtedly sufficiently accurate to meet the requirements of refrigeration engineering. The Clapeyron equation, however, offers a means of correlating the measurements of the latent heat of vaporisation [see Abs. 278 (1918)] with the data on specific volumes of saturated liquid and vapour, provided the slope of the saturation line can be determined with sufficient accuracy. On account of the large errors which may be introduced into the calculated values of the slope by relatively small errors in the pressure or temperature, it appeared that existing data were deficient either in the range or the precision required. The accuracy of vapour pressure measurements is determined in general by 4 factors which are first discussed, namely: purity of the material; certainty of equilibrium conditions; precision of the pressure measuring instrument; and temperature measurement and control. In measurements by the static method a very considerable lag in the attainment of equilibrium between the vapour and its liquid may be encountered even with a liquid well freed from impurities, especially if the liquid is not agitated. The presence of a small amount of permanent gas such as air greatly increases the lag in coming to pressure equilibrium. Section II of the paper deals with previous measurements, and curves are given representing the deviations of values computed by Regnault, Goodenough and Mosher, Holst, and Keyes and Brownlee. Section III gives a detailed description of the apparatus and method employed in the present measurements throughout the temperature interval − 78° to + 70° C. Section IV describes the purification of samples and details the manometer fillings. Seven samples of thoroughly purified ammonia were used. Special tests showed less than 1 part per 100,000 by volume of non-condensing gases present, and less than 0·01 % by weight of other impurities. Section V contains a description of preliminary experiments. Here the two phenomena of hysteresis due to impurities and lags due to other causes are studied, and the procedure adopted for the final measurements thereby determined. Section VI gives the measurements made by the static method and Section VII the determination of the normal boiling-point by the dynamic method. The mean of the results by the two methods was found to be − 33·35°. Section VIII discusses the form of the empirical equations, since widely different expressions have been proposed in the past century to represent vapour pressures as a function of temperature. Two empirical equations were found to represent closely the results in the temperature range covered experimentally, and also the latest determination of the critical data for ammonia. The results of 122 measurements in the interval − 78° to + 25° made with direct observations of mercury columns agree with the empirical equations within 1 mm. of mercury. The results of 28 measurements in the interval + 15° to + 70° made with an accurately calibrated piston gauge agree with the empirical equations within about 3 mm. of mercury. Section IX contains a discussion of results. The vapour pressure of ammonia is found to be expressed in the range − 80° to + 70° by either of the following equations :

$$\log_{10} p = 30\cdot256818 - 1914\cdot9569/\theta - 8\cdot4598324 \log_{10} \theta + 2\cdot39309 \times 10^{-3}\,\theta + 2\cdot955214 \times 10^{-8}\,\theta^2,$$

$$\log_{10} p = 12\cdot465400 - 1648\cdot6068/\theta - 0\cdot01638640\,\theta + 2\cdot403276 \times 10^{-5}\,\theta^2 - 1\cdot168708 \times 10^{-8}\,\theta^3,$$

where p is expressed in mm. of mercury and θ in degrees absolute. The slope of the vapour-pressure-temperature curve is obtained by differentiation of either of the above equations. Numerous tables of data are included in the paper. H. H. Ho.

736. *Oscillators of Two or Three Degrees of Freedom : A Contribution to the Quantum Theory.* **R. Gans.** (Ann. d. Physik, 61. 4. pp. 400–409, Feb. 22, 1920.)—In his work on the physical structure of the phase space, Planck has shown [see Abs. 347 (1916)] in what manner phase space may be analysed into probable zone elements. This result, aided by previous ones, serves for the determination of important thermodynamic functions for the case of oscillators of two and three degrees of freedom. The present paper deals with such problems, and compares the data from the formulæ obtained with practical results. This is necessary since the vibrations of particles are generally of more degrees of freedom than one. Section I deals with linear oscillators for the sake of comparing results with those for oscillators possessing two or three degrees of freedom. Section II considers oscillators having two degrees of freedom, and finds that such an oscillator of frequency ν is energetically completely equivalent to two linear oscillators, one of which is of frequency ν and the other 2ν. This has been experimentally found by Nernst and Lindemann, but not theoretically established by them. The author now finds this result to be valid only when the frequency can be freely chosen. Section III investigates oscillators having three degrees of freedom, and finds that such an oscillator of frequency ν can be energetically replaced by three linear oscillators of frequencies 2ν, $\frac{4}{3}\nu$, and $\frac{2}{3}\nu$ respectively. H. H. Ho.

SOUND.

737. *Kaufmann's Theory of the Impact of the Pianoforte Hammer.* **C. V. Raman** and **B. Banerji.** (Roy. Soc., Proc. 97. pp. 99–110, April 1, 1920.)—The theory of the vibrations of the pianoforte string put forward by Kaufmann in a well-known paper (Annalen der Physik, vol. 54, 1895) has figured prominently in recent discussions on the acoustics of this instrument. It proceeds on lines radically different from those adopted by Helmholtz in his classical treatment of the subject. While recognising that the elasticity of the pianoforte hammer is not a negligible factor, Kaufmann set out to simplify the mathematical analysis by ignoring its effect altogether and treating the hammer as a particle possessing only inertia without spring. The motion of the string following the impact of the hammer is found from the initial conditions and from the functional solutions of the equation of wave-propagation on the string. On this basis was given a *rigorous* treatment of two cases: (1) a particle impinging on a stretched string of infinite length, and (2) a particle impinging on the centre of a finite string; neither of which cases is of much interest from an acoustical point of view. The case of practical importance treated by him is that in which a particle impinges on the string near one end. For this case an *approximate* theory only was given and from it the duration of contact, the motion of the point struck, and the form of the vibration-curves for various points of the string, could be found.

The present paper is concerned chiefly with a revision and extension of the theory of the impact of the pianoforte hammer as developed by Kaufmann. It is pointed out that the approximate method, in which Kaufmann assumes that the part of the string between the striking point and the nearer end remains straight so long as the hammer is in contact, is unsatisfactory, and cannot be regarded as applicable when this part of the string is an appreciable fraction of the whole. It is shown how this assumption may be dispensed with, and the general case, in which an inelastic particle impinges at any point on the string, may be dealt with rigorously and subjected to numerical computation. An interesting result obtained is that the *duration of contact does not continually increase* as the striking point is removed from the end of the string, but is subject to discontinuous fluctuations. Experimental work, broadly speaking, confirms this indication of theory.

The present paper is preliminary to a more complete investigation which the authors hope to make. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

738. *Fundamental Formulations of Electrodynamics.* **G. H. Livens.** (Roy. Soc., Phil. Trans. 220. pp. 207–245, March 17, 1920.)—The author's objective is the formulation of a complete and precise statement of the Faraday-Maxwell theory in the only form in which it is logically consistent, and to compare this form with current statements of the theory, and exhibit in their true aspects the various derived theories included in the general scheme. The original differential theory is linked up with the subsequent dynamical theories by a discussion in its most general form of the fundamental equations based on the principle of least action, in the course of which certain inconclusive aspects of this derivation are considered. The great degree of latitude allowed by the theory in its simplest and most general form is very clearly shown. It is shown, moreover, that contrary to the view of nearly all continental writers on the subject, and others, the theory is of sufficient generality to include the cases complicated by non-linear induction in ferromagnetic media. This view seems to have originated with the idea that the *magnetic force* is the fundamental ethereal vector of the magnetic field. But the only consistent view of the energy relations leads to the conclusion that the *magnetic induction* is the true ethereal vector, the magnetic force being an auxiliary vector derived in averaging the minute current whirls in their effective representation as a distribution of magnetic polarity. A complete statement of the theory as given by Maxwell and in the form which will include most of the recent extensions depends on four fundamental vectors :—E, the *electric force* at a point is the vectorial ratio to a small charge of the force acting on it when at rest there. If the point be inside matter there may be a small additional contribution due to local matter : C, the *complete current* consisting of the true conduction and material dielectric displacement currents due to differential drift of free ions : the part due to convection of charged and electrically polarised media, and the ethereal constituent essential and peculiar to Maxwell's theory : H, the *magnetic force*, defined similarly to E, with the aid of the concept of a magnetic pole, but *without* the possibility of a local contribution : B, the *magnetic induction*, is the complete ethereal magnetic force, the part H being the mechanically effective part of B in the material media, with possibly an additional force $4\pi I$ (I = magnetic polarisation intensity) not directly detectable in a mechanical experiment). I and P, the dielectric polarisation intensity, are two subsidiary vectors defining respectively resultant magnetic and electric bipolar momenta per unit volume of the media. Maxwell's theory may then be expressed in the statement that in the most general case of interaction between the magnetic and electric fields the four fundamental vectors defining them are subject to the relations $\mathrm{Curl}\ H = 4\pi C/c$, $\mathrm{Curl}\ E = -B/c$, $\mathrm{div}\ E = 4\pi\varrho$, where ϱ is the electric charge density (the second relation practically implies that $\mathrm{div}\ B = 0$, so this is not an additional equation). Further development will require merely the kinematical specification of C in terms of the material vectors, and an expression for $\dot{H}$ at any point of the field. C is expressed in the usual form $C = \dot{D} + \varrho\gamma_m + C_1$, where C_1 is the density of the true conduction current, γ_m the velocity of the material medium at the typical field point, and $D = E/4\pi + P$ is the total dielectric displacement. When the dielectric media are in motion, $\dot{D} = \dot{E}/4\pi + \dot{P} + \text{Curl}\,[P\gamma_m]$. Analogously, $\dot{H} = \dot{B} - 4\pi\dot{I} - 4\pi\,\text{Curl}\,[I\gamma_m]$, an expression emphasised by the author as apparently not hitherto expressly introduced, although necessary to secure greater consistency in the dynamical theory. The arguments for the existence and form of the last term are on same lines as for $\dot{D}$. The fundamental dynamical equations are then derived from the least action principle, the assumption of a definite electronic constitution for the dielectric and magnetic polarisations being avoided in order to bring out points not hitherto adequately treated. Then, in addition to deriving the equation $\text{Curl}\,E = -\dot{B}/c$, it can be proved that the forces on the media occupying the field consist of: A part $\varrho(F + [\gamma_m B]/c)$, due to the free charges associated with the typical point of the matter, where F is the rate of dissipation of electromagnetic energy into energy of other types, *e.g.*, such as results mainly from inertia of the electric charges constituting the conduction and convection currents: a part $[CB]/c$ due to the true conduction current: a part due to dielectric polarisation whose x component is $(P\nabla)E_x + [\dot{P}B]_x/c - [P\gamma_m]\partial B/c\partial x$; and a part due to magnetic polarisation whose x component is $(I\nabla)B_x - [\dot{I}E]/c - [I\gamma_m]\partial E/c\partial x$. Except for the magnetic terms these results agree generally with those derived from electron theory, and this discrepancy is shown to arise from neglect of the convection of the magnetic polarisations. The dynamically derived results are examined in connection with radiation, energetics of magnetic media, and the fundamental representation of the forces in the field, as an applied stress system, and the subsidiary question of electromagnetic momentum. The slight discrepancies alone found, though probably of little or no practical significance, prove to be of theoretical import as helping to justify the equations on which they are based. The conception of electromagnetic momentum is not completely attained under the most general conditions—as is probably true of former presentations—but will remain as an effective expression of certain results of the simpler theory. The necessary supplementing of the theoretical relations by the usual empirical laws for the induction of the two polarisations and the conduction current are omitted in order to emphasise the independence of the complete theory of these laws, so that it covers the most complex fields involving ferromagnetic inductions and polarisations. If interpreted as determining the electrodynamic changes in the system during changes in configuration, even the presence of hysteretic qualities in the inductions will not invalidate it. G. W. de T.

739. *The Capacity Coefficients of Spherical Conductors.* **A. Russell.** (Roy. Soc., Proc. 97. pp. 160–172, April 15, 1920.)—Kelvin's series for the self-capacity coefficient k_{11} of a sphere is

$$k_{11} = a + b_1 + b_2 + \ldots,$$

where a, b are the radii of the two spheres, c the distance between them, $b_1 = a^2b/(c^2 - b^2)$, etc. It is proved that the remainder of the series after n terms can be expressed as the capacity of a spherical condenser and the value of this remainder can therefore be found to any required degree of accuracy. For instance, if we denote the capacity of a spherical condenser, the radius of the outer sphere of which is a, the radius of the inner sphere b and c the distance between the centres, by $F(a, b, c)$, then

$$b_1 + b_2 + b_3 + \ldots = F(a_1, b_1, c_1) \ldots\ldots\ldots\ldots \quad (1)$$

where $a_1 = a$, $b_1 = a^2b/(c^2 - b^2)$, $c_1 = a^2c/(c^2 - b^2)$. Similarly we have

$$b_2 + b_3 + \ldots = F(a_2, b_2, c_2) \ldots\ldots\ldots\ldots \quad (2)$$

where $a_2 = b_1$, $b_2 = b_1^2a_1/(a_1^2 - c_1^2)$, $c_2 = b_1^2c_1/(a_1^2 - c_1^2)$, and so on. For example, if the radius of each sphere be one cm. and the distance between their centres be 4 cm. we have

$$k_{11} = 1 + F(1, 1/15, 4/15) = 1 + 1/15 \, . \, F(15, 1, 4)$$

and by (1) and (2), $F(15, 1, 4) = 1 + 1/209 \, . \, F(209, 15, 4)$. We could proceed further in this way if necessary. Since $F(15, 1, 4)$ represents the capacity of a spherical condenser whose radii are 15, 1 and the distance between the centres of the spheres forming it is 4, we can assume without making a large error in the calculation of k_{11}, that the condenser is concentric, and thus

$$F(15, 1, 4) = 15 \, . \, 1/(15 - 1) = 1 + 1/14.$$

Thus $k_{11} = 1 + 1/14 = 1 \cdot 0714 \ldots$ Similarly if we assume that $F(209, 15, 4) = 209 \cdot 15/(209 - 15)$ we get $k_{11} = 1 + 1/15 + 1/194 = 1 \cdot 071821$, which is correct to the last figure. From (1) and (2) we see that

$$F(a_1, b_1, c_1) = b_1 + F(a_2, b_2, c_2).$$

Hence this gives us a simple relation between the capacities of two condensers and it will be seen that there is an infinite number of such relations. In general it will be found that the computation of the value of $F(a_2, b_2, c_2)$ is much less laborious than the computation of $F(a_1, b_1, c_1)$. It is proved that the capacity coefficient of a spherical conductor equals its radius, together with the capacity of the condenser formed by the spherical surface on the one side and the images in it of all external objects connected in parallel on the other side. Similarly if a conducting sphere be in a cavity of any shape in a conducting solid, the capacity of the condenser formed by the sphere and the boundary of the cavity equals the capacity between the image of the cavity in the sphere and the sphere itself.

The mutual coefficient between two spheres is given in terms of the capacity of a spherical condenser, and other relations between the various capacities used by engineers and physicists are proved.

Finally a method of finding the approximate value of the *capacity between a sphere and distant large conductors* is given. AUTHOR.

740. *Motion and Charge of Small Particles in Ionised Electric Field.* **F. v. Hauer.** (Ann. d. Physik, 61. 3. pp. 303–312, Feb. 3, 1920.)—It is here argued that in an ionised electric field a suspended particle takes from its ionic atmosphere an electric charge, whose sign depends upon the position of the particle in the field. The consequences of this are traced out in some detail. E. H. B.

DISCHARGE AND OSCILLATIONS.

741. *High-Vacuum Discharge.* **J. E. Lilienfeld.** (Ann. d. Physik, 61. 3. pp. 221–263, Feb. 3, 1920.)—In previous investigations of the high-vacuum discharge in cylindrical tubes the author has used a probe method. In the present research the subtraction method was employed, and three differently constructed arrangements were used. The results confirm the law of linear distribution of the fall of potential along the discharge axis. With one of the tubes used direct measurements of the potential followed the square law. A. W.

742. *Undamped Oscillating Systems.* **A. Blondel.** (J. de Physique, 9. pp. 117–151, April, and pp. 153–262, May, 1919.)—Undamped oscillations are divided by the author into three classes: (*a*) the really undamped oscillations (pendulum of a clock, electro-diapason, interacting telephone-microphone, etc.); (*b*) apparently undamped oscillations, actually consisting of a large number of partial discharges, each generating a train of damped oscillations (hissing arc, etc.), and (*c*) long-period oscillations, produced by the inversion of the driving force (series-wound dynamo and separately-excited motor). The present article deals only with the first class of oscillations. The conditions for stability are given by what is generally known as the criterium of Kaufmann, though indicated by the author nine years before Kaufmann. To avoid the oscillations becoming indefinitely large it is necessary that, from a certain amplitude upwards, the real parts of the roots of the equation be negative. This equation is linear if oscillations of small amplitude are considered. In this case, the above-said condition can be determined without solving the equation, as has been indicated by Hurwitz, by considering certain determinants of the coefficients, which determinants must be positive if the condition above-said is satisfied: inversely, if only one of said determinants is not positive, an oscillation of indefinitely increasing amplitude can exist in the system. The author applies the Hurwitz method to equations up to the sixth degree and finds afterwards the conditions for obtaining oscillations of zero damping; these conditions are developed for equations up to the sixth degree.

The oscillations of a pendulum and of a 3-electrode lamp belong to two different types. The oscillations of a pendulum are naturally damped, but at each oscillation an impulse is given to it, which compensates the damping. On the contrary, the amplitude of the oscillations of the audion tend to increase indefinitely, but at each oscillation a braking action intervenes which reduces the amplitude. These two conditions are illustrated by polar diagrams, as well as the conditions for the Duddell and hissing arcs. E. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

743. *Mutual Induction Coefficient of Rectangles and Squares.* **A. Esau.** (Ann. d. Physik, 61. 4. pp. 410–420, Feb. 22, 1920.)—A formula is derived for calculating the coefficient of mutual induction for two rectangles of unequal magnitude lying in parallel planes, the axes of the rectangles being coincident. The general formula includes several special cases, among which are Neumann's formula for two equal rectangles in parallel planes, and that of Martens for two squares lying in the same plane. Under the assumption that the ratios (distance apart)/(length of side) and (difference of lengths of sides)/(length of smallest side) are less than 0·25, a simple approximate formula is obtained. From the

tables and curves given the proper value of the mutual inductance can be readily obtained for any given value of the above ratios. From previous results [Abs. 149 and 434 (1920)] the self-induction coefficients can be found, and the coupling coefficient is then easily determined.
A. W.

744. *Variable Mutual Inductance Coils.* **A. Stefanini.** (N. Cimento, 19. pp. 69–75, Feb., 1920.)—In a former article [Abs. 2230 (1905)] the author described an apparatus for continually varying the intensity of an induced current, devised for measuring the degree of deafness of a person. One form which could also be employed for the same purpose is the usual form of mutual inductance coils, constituted by a small coil rotatable inside a much larger one. The intensity of the induced current varies according to the sinusoidal law; this type, however, would be cumbrous for practical medical uses. The author has, therefore, studied the law of variation of the intensity of the induced current in an apparatus analogous to the latter, but in which the movable coil was made as large as possible. The experiments were made by including the fixed coil in a battery circuit and reading the deflections of a ballistic galvanometer connected to the movable coil and for various positions of this. The results of the experiments showed that the intensity of the induced current varied proportionally to the angle that the axis of a coil forms with the plane of the other. The apparatus constructed has an external over-all diameter of 11 cm. and the movable coil is provided with a tap, so that 15 or 500 turns of it can be employed, according to the degree of deafness to be measured.
E. B.

745. *Accurate Measurement of Capacity and Self-Induction.* **G. Falckenberg.** (Ann. d. Physik, 61. 2. pp. 167–172, Jan. 15, 1920.)—The method employed is a differential one, and has a sensitiveness of the order of 2×10^{-8}. A vacuum tube is used as a source of undamped waves, the oscillatory circuit of the valve transmitter being loosely coupled with two intermediate circuits which are as symmetrical as possible. These circuits in turn are both coupled to a fourth circuit and are arranged so as to give a differential effect in this fourth circuit. A two-stage amplifier is connected across the capacity of the fourth circuit, and a galvanometer in the anode circuit of the second valve serves as indicator. The condenser whose capacity variations are to be measured is included in one of the intermediate circuits, and with care measurements can be effected of the increase due to the effect of pressure on the dielectric constant of the liquid between condenser plates.
A. W.

746. *Dependence on pressure of the Dielectric Constants of Water, Ethyl Alcohol, Methyl Alcohol, and Acetone.* **G. Falckenberg.** (Ann. d. Physik, 61. 2. pp. 145–166, Jan. 15, 1920. Habilitationsschrift, Rostock.)—In this paper the pressure coefficients of the dielectric constants of water, ethyl and methyl alcohols, and acetone have been investigated. The work of Röntgen, Ratz, and Ortvay is first discussed. The author has used Drude's arrangement for measuring the dielectric constants by means of stationary waves of high frequency, coupled with Rukop's method of electric oscillations having very small damping decrements. The experimental details are very completely described, after which the measurements are given accompanied by curves and data tables. The refraction constants $(n-1)/d$, $(n^2-1)/d$, $(n^2-1)/(n^2+2)d$, are calculated; for water and the two alcohols a good agreement at low and high pressures is found for the expression $(n^2-1)/d$. Lack of compressibility data for acetone prevented the corresponding calculations. For ethyl ether all three refraction constants in the pressure zone 1–500 atmos. show considerable deviations. The very great and in part negative values of the Wiener number u for water and the alcohols confirm the assumption made by Röntgen that during an increase of pressure the ratio between polymerised and unpolymerised molecules changes. This latter change contradicts the assumption on which the Weiner and also the Lorentz-Lorenz refraction constants were calculated. H. H. Ho.

747. *Absolute Double-sphere Electrometer.* **A. Guillet** and **M. Aubert.** (Comptes Rendus, 170. pp. 385–387, Feb. 16, 1920.)—Gives a numerical calculation of the characteristics of an electrometer formed by substituting a sphere for the conducting plane of an instrument previously described [see Abs. 1556 (1912)]. It is shown that while two equal conducting spheres charged to potentials of opposite signs always attract each other, if they are charged to potentials of the same sign, respectively V and v, the force between the spheres will be a repulsion, zero, or an attraction according as V/v lies between ϱ_1 and ϱ_2, is equal to either, or lies outside the interval between ϱ_1 and ϱ_2; where ϱ_1 and ϱ_2 are the roots of a quadratic equation with coefficients calculated from the characteristics of the system. **Erratum** (*Ibid.*, p. 771, March 22, 1920.) J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

748. *Moment of Inertia of the Magneton.* **R. Gans.** (Univ. de La Plata, Publ. [Mat. Fis. Ser.] 1. p. 383, 1916. Ann. d. Physik, 61. 4. pp. 396–397, Feb. 22, 1920.)—Experimental results by H. Isnardi in the author's laboratory show that the specific susceptibility of diamagnetic bodies is independent of the field. It follows according to the theory of Gans that the three principal moments of inertia of the magneton are equal to one another [Abs. 721 (1916)]. If it be assumed that the atom contains one magneton then the moment of inertia may be calculated from a knowledge of the atomic susceptibility. This is done for a number of elements. The values obtained are of approximately the same order, namely 1×10^{-43} gm. cm.^{2}. L. L.

749. *The Reversible Permeability for the Ideal Magnetisation Curve.* **R. Gans.** (Univ. de La Plata, Publ. [Mat. Fis. Ser.] 2. p. 145, 1918. Ann. d. Physik, 61. 4. pp. 379–395, Feb. 22, 1920.)—The author has previously defined a quantity "the reversible permeability" as the value of dB/dH, where dH is a small change in the magnetising force opposite in sign to the immediately preceding change in that quantity [Abs. 1845 (1908)]. He has measured this quantity on the original magnetisation curve and on the ascending and descending branches of the hysteresis loop and shown that it is a function of the magnetisation independent of the previous magnetic history of the iron. In the present paper investigations have been carried out on four ellipsoids of hard steel, soft steel, soft iron, and nickel. The first part of the paper contains data and curves for the original magnetisation curve, the ascending and descending branches of the hysteresis loop and the ideal "hysteresis free" curve proposed by

Steinhaus and Gumlich [Abs. 239 (1916)]. In the second part are values of the "reversible permeability" for these specimens observed on the original magnetisation curve and on the ideal "hysteresis free" curve. These data are plotted as ordinates against the corresponding values of the magnetisation as abscissæ, and show that the "reversible permeability" is the same function of the magnetisation whether points are selected from the magnetisation curve or the ideal curve. The reversible susceptibility, k_r, for every point in the I-H plane is determined by the following equations: $k_r/3k_0 = 1/x^2 - 1/\sin^2 x$, $I/I_\infty = \cot x - 1/x$, where k_0 is the initial susceptibility, and I_∞ the saturation value of the intensity of magnetisation. L. L.

750. *Magnetic Storm of March 22–23 and Associated Phenomena.* **C. Chree.** (Nature, 105. pp. 136–137, April 1, 1920.)—The sudden commencement at Kew Observatory was at 9h. 10m. on March 22. The H-trace was off the sheet several times, so the range of 810 γ was probably much exceeded; some movements were very sharp, a rise of 280 γ and a fall of 360 γ occurring in the period from 16h. 50m. to 17h. 15m. During part of the same period the declination swung 1° 35′ to the east and 44′ to the west. The whole range shown on the sheet was 2° 1′, and as the trace was off the sheet more than once, this may have been considerably exceeded. The vertical force trace was complete, showing a range of 820 γ. 27 days earlier a much smaller, but considerable, disturbance was recorded, lasting for ten hours [see Abs. 1427 (1919)]. **A. L. Cortie.** (Nature, 105. pp. 137–138, April 1, 1920.)—At Stonyhurst the sudden commencement was at 9h. 16m. on March 22. The H.F. magnet was frequently out of range of the photographic apparatus, the extreme range being greater than 700 γ, compared with a quiet-day range (Jan. and Feb.) of 18 γ. Rapid shiverings of the magnet were a feature of the storm later between 4h. 20m. and 8h. 50m. on March 23, these having a range of 130 γ. The storm after this ceased to be violent, but disturbances continued till midnight on March 25. The extreme range of the vertical force exceeded 900 γ, the trace being off the drum at times in the negative direction. The greatest positive value was 642 γ above normal. The greatest total range of declination was 2° 40′, one double swing reaching 2° 10′, and another 1° 30′. On the whole, increases were noted during daylight and decreases at night. The associated sun-spot group, visible from March 16 to 29, measured on March 22 rather more than 1/150 of the area of the sun's disc. During the previous solar rotation the spot was very inconspicuous though the magnets were disturbed. The spot-group was more conspicuous during the rotation before that.

The aurora on March 23 showed eight broad beams of light, most of them reaching within 5° or 10° of the zenith, the basis being from N.N.E. to W. by N., or about 100° of arc between 3h. and 4h. in the morning. **A. C. Mitchell.** (Nature, 105. p. 170, April 8, 1920.)—This storm was one of the most considerable recorded during the 9 years of registration at Eskdalemuir. Sudden commencement at 9h. 12m .G.M.T. on March 22 with motion in N. and W. components too rapid for photographic registration. About 17h. the extreme value of western declination was reached. It was off the sheet, but was estimated 1° 43′ from the normal position. After midnight large and rapid oscillations took place, one shift of 2½° towards the east from 1h. 20m. to 1h. 26m. The north component register was off the sheet in both directions at different times, total range exceeding 700 γ. The vertical force magnetogram showed four prominent maxima before midnight with a range of 565 γ, and after midnight it fell rapidly, remaining off the sheet for six hours. Pulsations afterwards occurred of unusual amplitude, a feature that requires explanation at the end of a storm. Aurora display reached within 30° of the southern horizon. W. W. B.

751. *Qualitative and Quantitative Laws of Radiotherapy.* **G. Mazérès.** (Archives d'Él. Medicale, 28. pp. 40-49, Feb., 1920.)—The general fundamental laws of radio-therapy may be arranged as follows :—A. *Qualitative laws*—(*a*) Radio-sensibility is a function of the cell which is being radiated by the same quality and quantity of radiation. The law which was discovered by Bergonié and Tribondeau is as follows :—All things on the side of radiating quality and quantity being equal, the radio-sensibility of living cells is so much the greater as (1) the karyokinetic activity is the greater, (2) the karyokinetic growth is longer, (3) the morphology and function are less definitely fixed. (*b*) In the cell the radio-sensibility is a function of the constituent chemical elements (Lafargne, Tribondeau, and Bordier). The radio-sensibility of the cellular albumen is so much the greater as that albumen belongs to a younger generation. It is the age factor of the cell which intervenes here in the sensibility of the cellular albumen. (*c*) For the same cell the radio-sensibility is a function of the quality of the radiation (wave-length). This law was discovered and demonstrated by Regaud and Nogier. With quantities of equal radiation cells of the same kind are unequally sensible to X-rays of different qualities: the radio-sensibility is a function of the wave-length of the radiation, that is, of its frequency.

B. *Quantitative laws*—(*a*) Law of weak quantities (Zimmern and Marie). With a weak dose and constant quality X-rays have an exciting effect upon cellular evolution and the functioning of the cell. (*b*) Law of strong quantities (Beclère). All living cellular elements, healthy or diseased, having absorbed a sufficient quantity of X-rays, become the seat of chemical transformations of which the last stage is degeneration and death. (*c*) Law of bio-chemical action and X-radiation (Guilleminot). The biochemical action of a radiation depends, not on the absolute quantity of radiant energy fixed per unit of mass of tissue, but on the absorbability of this radiation by the cellular albumen at the depth considered. The efficacious dose per mm. D_e is the product of the coefficient of albuminoidic absorbability K by the incident dose transmitted D_i; $D_e = K . D_i$. This law is from the quantitative point of view the homologue of the law of albuminoidic sensibility. (*d*) Law of reaction in function of the distribution of the X-rays. There is a constant ratio between the cellular reactions to absorbed doses and the mode of distribution with rapid or slow decrease of the quantity of radiation in the depth of the tissues. From experiments on the action of radiations upon a colloid (oxide of phosphorus in solution in benzine), Bordier and Galimard have obtained results which have enabled Bordier to establish the bio-chemical theory upon the action of X-rays which is described in this paper. This law is not a new one, but is simply built up from the three known laws: that of distances, that of filters, and that of quantities in function of the time. This enables the duration of exposure to be obtained rapidly. An arrangement is described which enables the calculation of the exposure to be made automatically in function of these factors. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

752. *Possibility of Separating Lead Isotopes by Centrifuging in the Liquid State.* **J. Joly** and **J. H. J. Poole.** (Phil. Mag. 39. pp. 372–375, March, 1920.)—Since it has been discovered that both the uranium and thorium families yield elements which are isotopic with ordinary lead but differ from it slightly in atomic weight and density, it has often been suggested that lead itself is not a homogeneous element, but consists of a mixture of isotopic uranium and thorium lead. This view of the constitution of common lead is based on the fact that both its atomic weight and density are found to be intermediate between those of its two isotopes, and that therefore an appropriate mixture of the two isotopes would have the same mean atomic weight and density as ordinary lead. If this view of the real nature of lead were correct, it would seem to be possible that some separation of its two constituents which would differ by about 1 % in density, might be effected by centrifuging the lead while in the liquid state. Such a separation could be most easily detected by determinations of the density of the lead from the top and bottom of the centrifuging tube. This method has been adopted in the experiments now described. Details are given of the centrifuge, method of heating the lead, order of experiment and method determining the density of the samples of lead taken from the centrifuge.

The results indicate that there is absolutely no evidence for the separation effect, the density of the "top" and "bottom" lead samples agreeing within experimental error. The authors discuss the possible explanation of this negative result. On the basis of certain observations of Lindemann and Aston, they calculate that a difference of density of 0·005 % should exist between top and bottom layers on the centrifuge at its highest peripheral speed of 10^4 cm./sec. This difference is too small to be detected by the method employed. It is suggested that a specially constructed centrifuge giving much higher peripheral speeds might succeed. A. B. W.

753. *Centrifuging Alloys in the Liquid State.* **J. Joly** and **J. H. J. Poole.** (Phil. Mag. 39. pp. 376–383, March, 1920.)—During the course of experiments to separate lead isotopes by centrifuging [see preceding Abs.], certain alloys were also dealt with. The results obtained are given in a table. It was found that in the case of Ag-Pb alloys no definite separation could be obtained. These alloys were dealt with especially since, if silver and lead could be separated by centrifuging, the process might be cheaper and more expeditious than the existing cupellation method. Unfortunately the method in this case proved a failure. In the case of other alloys, Pb-Sn and Pb-Sn-Bi, an undoubted separation was effected. A. B. W.

754. *Whole-Number Isotopes and Allied Phenomena.* **F. H. Loring.** (Chem. News, 120. pp. 73–77, Feb. 13, 1920.)—F. W. Aston [Abs. 265 (1920)] remarks: "A fact of the greatest theoretical interest appears to underlie these results, namely, that of more than forty different values of atomic and molecular mass so far measured, all, without a single exception, fall on whole numbers . . . due allowance being made for multiple charges." The results given are as follows :—

Carbon—No isotopes ; atomic weight, 12 exactly.
Oxygen—No isotopes ; atomic weight, 16 exactly.
Neon—Two isotopes ; atomic weights, 20 and 22.
Chlorine—Two isotopes ; atomic weights, 35 and 37.
Mercury has several isotopes round 200, but accurate values cannot be given.
Hydrogen has not yet been measured.

These results, combined with that of Rutherford in the case of nitrogen, are of fundamental importance, and form a proof of Prout's hypothesis. In addition to the above information, the spectroscopic findings of T. R. Merton [Abs. 374 (1920)] are of considerable interest, giving valuable data relative to the isotopes of lead and thallium and providing a method of distinguishing isotopes spectroscopically.

In the light of the experimental evidence referred to above, the author discusses general isotopic theory in its relation to photoelectric phenomena and the cyclic evolution of the elements. On the basis of isotopic theory, the author analyses all the apparent inconsistencies in the periodic table, showing how the difficulties disappear now that the principle of isotopy is found to apply to the atoms of ordinary elements. In earlier papers [Abs. 1567 (1919) and *Ibid.*, p. 281, 1919] the question of "isotopes and electric conductivity" had been dealt with. A. B. W.

755. *Inter-Relationship of the Chemical Elements.* **H. Collins.** (Chem. News, 120. pp. 169-170, April 9, 1920.)—The author remarks on certain coincidences relating to the atomic weights and valencies of the elements, showing that certain series of elements arranged in pairs have a constant value for the sum of the atomic weight of the pairs. Thus, $Mg^{II} + Al^{III} = 51$, $Na^{I} + S^{IV} = 51$, etc. Three series of this kind, Va = 51, Cr = 52, Mn = 55, approximating to the atomic weight of vanadium 51, are tabulated, and it is shown that these three sets of coincidences are *due to causes and not to chance*. The first and second sets of coincidences are concerned with atomic weight and valency, whence it is evident that there is a definite connection between mass and valency. The connection between the two has been shown in a previous paper (Chem. News, Dec. 26, 1919), namely: Each one of a large number of elements is composed of one or more portions of masses 1, 3, 7, 23, and 39, from each of which emanates one valency.

The third set of coincidences is solely concerned with atomic weight, and the author explains this case by assuming that there is some "unknown source of error which causes the atomic weights in general to be estimated as greater than they really are."

Although the three elements V = 51, Cr = 52, and Mn = 55 have been chosen arbitrarily out of the 83 recognised elements, the author considers it is quite correct to reason upon the facts concerning them independently of those concerning other elements, so long as the coincidences with regard to them can be shown to be so extraordinary as to be altogether removed from the possibility of chance. And no exceptions, however numerous, that may be observed with regard to other elements can affect the matter in the slightest. The author refers to his discovery as "the Inter-relationship of the Chemical Elements," considering it a much larger generalisation than the periodic classification.

A definite reason for the apparent inapplication of this inter-relationship to the cases of some elements of high atomic weight is to be given in a later paper. A. B. W.

756. *Energy-Change in Photochemical Processes.* IX. *Photochemical Transformation of Isomers.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Ber. 50. pp. 960–974, Dec. 11, 1919. From the Physikal-Techn. Reichsanstalt.)—Maleic acid, $C_4H_4O_4$, melting-point 130°, passes when heated into the isomeric fumaric acid, m.p. 286°, which is the more stable form. The author exposes aqueous solutions of the acids for 10 to 40 minutes to radiations of $\lambda 0 \cdot 0207$, $0 \cdot 253$, $0 \cdot 282\ \mu$; the isomeric change is tested by the electrolytic conductivity (bridge and Schering-Schmidt galvanometer). The cell of $2 \cdot 5$ cm.^{3} is built up of two quartz discs separated by a flat horseshoe of quartz and lightly screwed together; the contents are stirred or not during exposure; the mere stirring does not influence the resistance. Only a small percentage of the absorbing molecules appears to be transformed by the light; there is no decomposition apart from the isomeric change. As the λ increase, the φ [see Abs. 879 (1918) and 645 (1919)] increase for fumaric acid and decrease slightly for maleic acid. The two isomers behave differently in this respect as in several others. The author suggests that the heat absorbed drives the constituents of the molecules apart, and that this constitutes the primary radiation process; during the secondary independent process the molecules, which may be left in different conditions, return to the original or to the isomeric state, mostly to the former. The quantum theory is a useful guide as to the reactions, but does not admit of quantitative conclusions. H. B.

757. *Quantum Theory of Photochemistry.* **E. Warburg.** (Zeits. Elektrochem. 26. pp. 54–59, Feb. 1, 1920. From the Physikal.-Techn. Reichsanstalt.)—Photochemical reactions are produced only by the absorbed radiated energy and are proportional to it, the specific photochemical effect φ being expressed in gm. cals. absorbed [Abs. 645 (1919)]. The φ may be referred to the decomposed product or to the decomposed mass of the photolyte; primary and secondary reactions must be distinguished as in electrolysis. Einstein's law of equivalence holds only when the absorbing substance has itself the frequency ν, the number p of molecules of the photolyte concerned in the absorption of one gm.-cal. being then $p = A. h. \nu = \lambda/1 \cdot 987c$, where A is Avogadro's number and $c = 14,300$. Faraday's law has its parallel in the valency-radiation $= 1/p$ which must be absorbed in order to act photochemically on one gm.-mol.; the indicated photochemical equivalent is the number of molecules concerned, the effective photochemical equivalent is the number of molecules decomposed or transformed into isomers by 1 gm. cal. after the completion of the primary and secondary processes; $j = \varphi/p$ is the efficiency ratio. According to Einstein's photochemical equivalence each absorbing molecule would primarily be decomposed or transformed; but in general some of the molecules concerned are not primarily affected, because (1) the valency-radiation is smaller than the molecular work of decomposition, (2) energy is given off during the absorption, and (3) the chemical transformation is a secondary process, as in the photolysis of isomers. H. B.

758. *Ammonia Synthesis at very High Pressures and its Advantages.* **G. Claude.** (Comptes Rendus, 169. pp. 1039–1041, Dec. 1, 1919, and 170. pp. 174–177, Jan. 19, 1920.)—Haber's equilibrium formula not admitting of extrapolation to very high pressures, the author experiments with mixtures of N and H, free of oxygen, but not rigorously dried. Raising the pressure in steps of 200 atmos. to 1000 atmos., he finds that the concentration of NH_3 rises finally to 25 % and the combination ratio to 40 %. This high concentration involves various advantages, upon which the author dwells with reference to the Haber process. He only sends his gases 3 times (not many times) through the catalyst, and the yields of an ammonia of much higher concentration claimed per gm. of catalyst are many times higher than those of Haber. There are also advantages in connection with the removal and the fixation of the ammonia, with respect to which he refers to the Schreib process as adapted to the preparation of ammonium chloride (not sulphate) for fertilisation [see Abs. 673 B (1919)]. Like Haber he works at 600° because the velocity of the reaction is too small below 500°, and the ammonia concentration too low above 700°. It is mentioned that the removal of the heat of reaction requires special measures. The only technical detail given is that the catalyst is a fine-grained substance placed in tubes 10 cm. long, 8 mm. in diameter. H. B.

759. *Absolute Saturation of the Attractive Forces between Atoms and Molecules.* **M. Polanyi.** (Zeits. Elektrochem. 26. pp. 161–171, April 1, 1920.)—The author introduces his paper by stating that in chemistry and physics, ideas concerning saturation are very indefinite, and he now puts forward certain theoretical aspects of a special case which he designates as "absolute saturation." Section I deals with the form and province of phenomena. Here terms receive definition, and the attractive forces between atoms and molecules are held to exhibit what is understood by absolute saturation. It is then established from adsorption measurements that such absolute saturation really occurs, and a series of phenomena are given to show the general characteristic of absolute saturation with respect to interatomic (or molecular) forces. Theoretical considerations are advanced in section 2, for non-additive fields of force; and the heat of formation of a molecule is shown to vary according to its position in the field. A dipole scheme is investigated in section 3, and it is shown that homogeneous interatomic or molecular fields are non-homogeneous electrical fields; that such fields show absolute saturation; and that the molecular heat of formation is dependent on position in the field when this is homogeneous. H. H. Ho.

760. *The Octet Theory of Valency and its Applications, with Special Reference to Organic Nitrogen Compounds.* **I. Langmuir.** (Am. Chem. Soc., J. 42. pp. 274–292, Feb., 1920.)—The octet theory of valency [Abs. 991 (1919)] is here applied particularly to organic nitrogen compounds, the general application of the theory to inorganic nitrogen compounds and salts being also discussed.

The number of available electrons in the outside shell of any atom is usually given by the ordinal number of that column of the periodic table in which the element is found. This number, E, corresponds with the max. positive valency of the ordinary valency theory and is 1 for sodium, 4 for carbon, 5 for nitrogen, 6 for oxygen, and 7 for chlorine.

It is readily proved that the octet theory is entirely in agreement with the ordinary theory of valency whenever the ordinary formulæ are based on valencies of unity for hydrogen and (8—E) for each other element, that is, 4 for carbon, 3 for phosphorus and nitrogen, 2 for oxygen and sulphur, 1 for chlorine, bromine, etc. On the other hand, all formulæ in which valencies different from these have been used require modification according to the octet theory. According to this theory all salts are completely ionised even before they are brought into solution. This conclusion is, however, in agreement with recent work of Milner (Phil. Mag. 35. p. 354, 1918), Ghosh [Abs. 881 (1918), 104 (1919)], and others, and explains why there are weak acids and weak bases but no weak salts. The known cases of isomerism, including stereo-isomerism, of nitrogen, phosphorus, and sulphur compounds are in full accord with the octet theory. The fact that organic cyanates, cyanides, and nitrates exist in two isomeric forms, whilst the corresponding inorganic salts exist in only one form, is explained, since the nulcovalent atoms of the metals in the inorganic compounds are not attached to definite atoms of the acid radicals. The available data on phosphonium, arsonium, sulphonium, and oxonium compounds are in full accord with the octet theory, which gives for these compounds constitutions closely resembling those previously given by Werner. T. H. P.

761. *A New Occurrence of Pro-eutectoid Ferrite.* **C. Y. Clayton.** (Am. Inst. Mining Eng., Bull. No. 159. pp. 1–8, March, 1920.)—Describes an unusual occurrence of pro-eutectoid ferrite in cast nickel-steel runners. The steel contained approximately 2·7 % nickel and 0·35 carbon. The macrostructure was of the usual type and showed slight segregation of ferrite near the edges of polyhedral grains. Swirls or eddies of pro-eutectoid pearlite were found in all parts of the runner and in all parts of the individual grains. A possible explanation of these swirls of ferrite is that the whirling motion of the molten steel in the runner causes the tips of the dendrites to be rounded at different periods of crystallisation due to resolution. Upon these rounded points, low-carbon austenite would be deposited due to selective freezing. C. O. B.

762. *Some Tests of Light Aluminium Casting Alloys ; Effect of Heat-Treatment.* **P. D. Merica** and **C. P. Karr.** (Bureau of Standards, Technol. Papers, No. 139 [29 pp.], Washington, 1919.)—The importance of precise specification of the form of test-piece for these alloys is emphasised and seven different types of test-piece are examined. The max. temperature at any stage of the melting should not be allowed to exceed 850° C. and a max. casting temperature of 700° C. is suggested. The report deals chiefly with alloys of Al with Cu up to about 3½ %. The addition of 0·4–1·3 % of magnesium to such an alloy results in an increase of 10–20 % in the tensile strength and a remarkable reduction, 60–80 %, in the elongation. For tenacities up to 18,000 lbs. per sq. in. the copper alloy is sufficient, but where a strength of 25,000 lbs. per sq. in. is required Ni or Mn must be added in addition. The addition of Si to aluminium reduces the elongation and increases the "notched-bar" brittleness. Heating the castings to 500° C. for 2 hours, followed by cooling in air, increases the tensile strength of good bars from 5–50 %. The effect of such heat treatment is increased by the presence of magnesium. When broken in tension these alloys usually fracture along the crystal boundaries.

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The tensile strength bears, therefore, little direct relationship to the hardness. The microstructure of the alloys and some account of the resistance to corrosion in the salt spray test are considered together with a brief examination of the resistance to alternating stresses. A very large number of tensile tests are tabulated. F. C. T.

763. *Expansion of Alloy Steels.* **J. A. Mathews.** (Am. Inst. Mining Eng., Bull. No. 158 [4 pp.], Feb., 1920.)—Gives, for alloy steels suitable for use in crankshafts, axles, etc., the analyses, tensile properties, hardness and shock test values, and the coefficients of expansion for two ranges of heating, viz., 25° to 100° C. and 25° to 270° C. The heat treatment was the same in every case, viz., hardening from about 840° C. and quenching in water until black, and then immediate drawing to about 570° C. Under these conditions the max. variation in the expansion coefficient was 1·34 parts per million per 1 deg. C. The coefficient of expansion is not in itself a primary cause of distortion in heat treatment, although in general, hardening from a temperature just about that at which the max. contraction takes place at decalescence tends to improve the final results of hardening so far as distortion is concerned. J. W. T. W.

764. *Influence of Cadmium on the Properties of Brass.* **L. Guillet.** (Rev. de Mét. 16. pp. 405–415, Nov.–Dec., 1919.)—The conclusions drawn from three series of experiments on the effect of cadmium on the mechanical properties of alpha and beta brasses are: (1) that 1 % cadmium has very little effect on the properties of the 70 : 30 and 60 : 40 alloys; (2) the first effect is felt in the lowering of the ductility of the metal, higher percentages cause a reduction in the tenacity; (3) the modifications in the mechanical properties are accompanied by the appearance of structurally free cadmium which appears in filaments having a tendency to surround the grains. With higher percentages spherical agglomerations recalling the appearance of lead in brass are formed; (4) the coefficient of equivalence of cadmium is about 0·7; (5) manufacturers and users of brass need have no fear of cadmium so long as the content does not exceed 1 %, a figure which is never reached in practice.

F. C. A. H. L.

765. *Sulphur and Phosphorus in Steel.* (Eng. News-Record, 84. p. 260, Feb. 5, 1920.)—Announces an organised research on a large scale with a view of determining the effects of sulphur and phosphorous on the quality of steel. C. O. B.

766. *Micro-contraction Cavities in Steel Ingots.* **G. Charpy.** (Comptes Rendus, 170. pp. 306–311, Feb. 9, 1920.)—Deals with the occurrence of micro-contraction cavities in steel ingots which form during the solidification of isolated portions of the metal and are similar to the pipes found in ingots. These micro-cavities are found in larger quantities near the centre of the ingots. The author shows that by forging these cavities are readily welded up, as their sides are free from oxidation. In the case of rolling, the first effect may be to open up the cavities and render their presence more serious. C. O. B.

767. *Radiometallography.* **H. Pilon** and **G. Pearce.** (Faraday Soc., Trans. 15. pp. 47–51, Feb., 1920. Engineering, 107. pp. 610–611, May 9, 1919.)—Information on the practice of metallography and on the results obtained in the works of Schneider-Creusot, the Cie. des Charbons de Nanterre, and others with Pilon apparatus and with the stereo-fluoroscope and other instruments of Watson and Sons. With double-coated films placed between intensifying screens a difference in thickness of 0·1 mm. can be determined through 45 mm. of steel, and the use of intensifying screens shortens the exposures very materially. Remarkable radiographs of internal-combustion motors, commutators, bearings, shells, etc., were shown. H. B.

768. *X-Ray Examination of Metals.* **E. Schneider.** (Faraday Soc., Trans. 15. pp. 32–34, Feb., 1920. Engineering, 107. pp. 613–614, May 9, 1919.)—The normal working current in the Coolidge tube used in the Schneider laboratories at Le Creusot is 4 milliamps. with a spark-gap of 25 cm., corresponding to 120,000 volts across the terminals. This permits of the penetration of 40 mm. of steel. Examination of fish plates cast with and without the addition of Al show the influence of the latter element in conferring soundness on steel. Tungsten steels are less permeable to X-rays than ordinary carbon steels, and the permeability decreases with increasing tungsten content. The method has been applied to the examination of ingots of Al alloys to determine the limit of the pipe so as to get proper cropping. F. C. A. H. L.

769. *Metals and Non-Metals.* **A. Smits.** (K. Akad. Amsterdam, Proc. 22. No. 2. pp. 119–125, 1919.)—The negative charge which zinc assumes when immersed in an electrolyte is usually explained as due to the simultaneous splitting up of the zinc atom into zinc ions + electrons, in accordance with the equation $Zn \longrightarrow Zn^{\cdot\cdot} + 2\ominus$, the zinc ions only going into solution whilst the negatively charged electrons remain in the metal. A similar explanation for the chlorine electrode would lead to the equation $Cl_2 \longrightarrow 2Cl' + \oplus$, chlorine ions going into solution and positive electrons remaining behind on the chlorine electrode. This latter explanation is doubtful, however, since free positive ions have not been met with, and everything points to the existence of the negative kind only of electrons. To obviate this difficulty the author assumes that the chlorine atom possesses the power both to split off and absorb electrons, in accordance with the equations:

$$(1)\ xCl_2 \rightleftarrows 2xCl^{\cdot} + 2x\ominus\ ;\ (2)\ yCl_2 + 2y\ominus \rightleftarrows 2yCl',$$

X and Y indicating the fractions of the original number of chlorine molecules which have undergone positive and negative ionisation respectively. Since the electrons which are absorbed according to (2) proceed from the ionisation represented in (1), it follows that $y \leqq x$. Since chlorine is a non-metal, x and y are exceedingly small. The positive charge of the chlorine electrode is then explained by assuming that it is the negative ions which go into solution practically exclusively, so that they possess a much greater solubility than the positive ions.

Similar considerations to the above are applied by the author to the cases of metals, and non-metals generally, and to the polarisation of non-metals. This latter is really "supertension" or overvoltage in the case of gases, but it is not essentially different from the phenomenon of anodic polarisation for metals. T. S. P.

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770. *Conductivity of Solid Salts and Salt Mixtures.* **R. Ketzer.** (Dissertation, Leipzig, 1919. Zeits. Elektrochem. 26. pp. 77–84, Feb. 1, 1920.)—According to Fritsch (1897) salt mixtures conduct many times better than the pure salts; the observations were questioned by M. Le Blanc (1912). The author compresses the powdered pure salts by hand into dry pastilles and makes his electrodes of polished copper amalgamated with mercuric nitrate; the resistance became mostly constant within a few days in a thermostat over P_2O_5. For the preparation of the mixtures he rejects one of Fritsch's methods (allowing the precipitated salt to settle on metal-coated glass) and powders the dry salts in an agate mortar. Experimenting chiefly with $PbCl_2$ and $PbBr_2$ he finds that the addition of NaCl or KCl (both very poor conductors when dry and solid) raises or lowers the conductivity very slightly; he therefore considers Fritsch and his theory as disproved. He finds, however, that the previous treatment of the powders before compression, especially heating to about 300°, may raise the conductivity very much. $PbCl_2$ itself conducted 10 and 20 times better after heating, and it mattered little whether the heating was effected in dry or moist air, in a vacuum, in nitrogen or in chlorine, though there were indications of chemical changes. When the $PbCl_2$ was mixed with the alkali chloride before heating and compressing, the conductivity might be raised several hundred times, and there was no proportionality between the conductivity change and the proportions; sometimes 0.001 % NaCl improved the conductivity 45-fold. H. B.

771. *Flame Reactions of Selenium and Tellurium.* **H. B. Weiser** and **A. Garrison.** (J. Phys. Chem. 23. pp. 478–497, Oct., 1919; Chem. News, 119. pp. 206–208, Oct. 31, and pp. 214–217, Nov. 7, 1919.)—J. Papish (J. Phys. Chem. 22. pp. 430 and 640, 1918) having extended the work of Bancroft and Weiser [see Abs. 1005 and 1467 (1914)], by showing that the coloured flames deposit Se and Te on a cold object (a porcelain dish) held in the flame, the authors resumed their experiments, passing first, after Papish, hydrogen through a hard-glass tube, in which SeO_2, H_2Se, or Se, is heated, and by igniting the hydrogen at the upturned end of the tube. The flame is light blue inside and red outside, with a dark bluish shell and a greenish tip. In flames cooled by much SeO_2 or by a copper coil the blue predominated strongly. Experiments were also made with salts of Se and Te in Bunsen flames, flames of air burning in hydrogen, of chlorine in hydrogen, with Se burning in air (blue flame), and with kathode rays. In hydrogen selenium itself did not luminesce when bombarded by the rays, but the vapours showed a reddish glow; in the presence of oxygen Se gave a blue and also red luminescence; when SeO_2 was bombarded in oxygen, the light was a stronger blue. It is concluded that the reaction from selenium to selenic salt produces a blue luminescence, which is most characteristic of Se and is ascribed to the conversion of selenic ion into undissociated selenic salt. Tellurium shines green when Te passes into tellurous salt, and blue when this is further oxidised to telluric salt. The reddish light of the vapours of both elements seems to be due to the vapours themselves and to a purely thermal luminescence. The reverse reactions do not appear to give rise to luminescence. The violet tint sometimes observed is due to a combination of blue and red, and is not a luminescence. The greenish top tip of the Se and Te flames is not a distinctive luminescence either, but due to the colour of the vapours of the dioxide, which appear more green by reflecting the blue luminescence below. Attention is drawn to the modification of flame colouration by varying the amount of the substances. H. B.

772. *Applicability of the Gas Law to Strong Electrolytes.* **J. N. Brönsted.** (Nobelinst. Meddel. [Arrhenius Festskrift] 5. (No. 25) [19 pp.], 1919.)—The deviations from the gas laws shown by strong electrolytes disappear when the solvent is itself not a pure substance, but a salt solution having an ion in common with the electrolyte, provided the salt concentration be large compared with that of the electrolyte. When potassium hydrotartrate and potassium hydroracemate are dissolved in KCl solution, the solubility ratio of the two salts approaches a constant value as the KCl is more concentrated, and the affinity of the racemic transformation between the two salts can be deduced from the gas laws. This relation should hold generally and is further proved by electrometric measurements in cells in which the liquid-liquid potential is practically negligible of the type:

$$\text{Cd-amalgam}\;\left|\;\begin{matrix}\mathrm{CdSO_4}c_1\\ \mathrm{MgSO_4}(2-c_1)\end{matrix}\;\right|\;\begin{matrix}\mathrm{CdSO_4}c_2\\ \mathrm{MgSO_4}(2-c_2)\end{matrix}\;\Big|\;\text{Cd-amalgam Th}$$

The concentration of the two amalgams was 3·1 %, the concentration of the cadmium sulphate c_1 and c_2, ranged from 0·1 to 1/640 molal. There are also further solubility experiments made with the α and β modifications of dinitrotetramin cobalt nitrate $\mathrm{Co}\begin{bmatrix}(\mathrm{NO_2})_2\\(\mathrm{NH_3})_4\end{bmatrix}\mathrm{NO_3}$. The ratio of the two solubilities c_α/c_β in water is 1·106, and the ratio has nearly the same value (very slightly smaller) in potassium formate, rhodanide, hydroxide, and in sodium oxalate; in nitric acid and potassium nitrate, however, the ratio is 1·2; only the latter solvents have an ion in common with the cobalt salt. The ratios given refer to 0°; at 20° both are higher. If the e.m.f. observed agree with those deduced from the gas laws by introducing the total concentration of the cadmium sulphate assumed to be partly dissociated, then the gas law must hold for the undissociated salt as well as for the cadmium ion. For strong electrolytes Bjerrum and S. R. Milner assume complete dissociation in aqueous solution; that would simplify the considerations and agrees best with the solubility experiments.

The deviations of strong electrolytes from the gas law must, then, be produced by the electrostatic forces due to the charges of the ions. These forces diminish the chemical potential π, and with increasing concentration c the salt potential must hence increase less than it should according to the gas laws. In the equation

$$\pi = \mathrm{RT}\log c + i$$

the arbitrary constant i must hence decrease with increasing concentration. H. B.

773. *An Attempt to Extend Planck's Theory to Dilute Solutions.* **P. Boedke.** (Ann. d. Physik, 61. 4. pp. 334–352, Feb. 22, 1920.)—Planck has shown that the further evaluation of the series evolved by him for the fundamental thermodynamic functions may afford a practicable method for the development of a rational thermodynamic theory of solutions for any given concentration. Jahn has also attempted to construct the mathematical theory of solutions in this direction. While

Planck's theory for the ideal dilute solution only involved terms of the first order in the above series, Jahn investigated the influence of terms of the second order. His results, however, were incomplete and referred only to certain characteristic phenomena in more concentrated solutions. The investigation of terms of the third order is not only tedious, but does not appear to give lucid results of a simple character, and the author now employs another mode of attacking the problem. In this he investigates the series development of the thermodynamic functions by a different argument from that employed by Jahn, and chosen in order to afford a better convergence of the series. For establishing the limits to the method, the phenomena of saturation and critical solubility in binary liquid mixtures are investigated, as being especially suitable for the purpose since the Planck and Jahn equations are applicable. Section 1 contains the series development of the Planck Φ function. Section 2 investigates the general conditions of equilibrium for a binary mixture. Section 3 deals with applications. In Section 4 a general form of the saturation equation is given. The Planck-Jahn equations afford a formulation of the changes of state in the two conditions of great dilution for such binary mixtures, but the same equation does not admit of following continuous changes of concentration between the two limiting cases. The author opines that the series derived by him may solve this condition, but reserves his judgment for a more thorough investigation.

H. H. Ho.

774. *Heat of Solution and the Partial Molal Heat Content of the Constituents in Aqueous Solutions of Sodium Chloride.* **M. Randall** and **C. S. Bisson.** (Am. Chem. Soc., J. 42. pp. 347–367, March, 1920.)—The partial molal heat content of a substance in solution is defined as the increase in the heat content of a large amount of the solution at the given concentration when one mole of the substance is added to it. The apparatus used consisted essentially of twin calorimeters, made of well-silvered vacuum-jacketed flasks, completely enclosed in a constant-temperature air jacket. Temperatures were recorded by special thermo-couples, and the liquids in the calorimeters could be well stirred. Full details of the calorimeter, and of the thermo-couples and their calibration, are given. The specific heats at 25° of solutions of sodium chloride, varying in strength between 4·03 and 6·20 molar (weight), altered from 0·821 to 0·779, the relation between specific heat and concentration not being a linear one. For solutions of potassium chloride (2·73 to 4·85 molar), the specific heats varied from 0·803 to 0·710, the relation again not being linear. The results of the measurement of the heat absorbed when water was added to solutions of sodium chloride varying in strength from 3·57 to 6·12 molar are given, the temperature being 25°, and from these the partial molal heats of solution of water in solutions of sodium chloride are calculated. Measurements of the heats of dilution of solutions of sodium chloride gave for the dilution of 6·12-M, NaCl: to 0·555-M, 560 cals.; to 0·370-M, 594 cals.; to 0·278-M, 604 cals.; to infinite dilution, 606 cals. The heats of solution of sodium chloride in water, giving solutions the final concentrations of which varied from 0·1266-M to 0·5400-M, varied between 970 and 1018 cals. absorbed per mole of sodium chloride dissolved. From the results obtained the partial molal heat of solution and the partial molal heat content of sodium chloride in its aqueous solution are calculated for various concentrations, and also the functional relation between the values of the partial molal heat content of the water and of the sodium chloride in the solutions. T. S. P.

775. *Sorption of Hydrogen by Palladium at Low Temperatures.* **J. B. Firth.** (Chem. Soc., J., Trans. 117. pp. 171–183, March, 1920.)—From a consideration of previous investigations [Abs. 1970 (1913); 1907 (1914)] the author concludes that the existence of at least two allotropic modifications of palladium has already been proved, namely, α-, or amorphous, palladium, and β-, or crystalline, palladium. The α-form is highly active and is responsible for rapid occlusion at temperatures up to about 150°; it is further capable of acting as a carrier to the β-variety, which may be completely passive or moderately active, according to the conditions of temperature. It is now shown that ordinary Pd foil is inactive towards hydrogen, both at the ordinary temperature and liquid-air temperature, even after it has been heated to a red heat in a vacuum for periods up to one hour. If palladium foil is oxidised by heating in the air for two hours, put into a silica bulb and exhausted, and then a small quantity of hydrogen added, the oxide is immediately reduced. If it is then immediately exposed to hydrogen at the ordinary temperature, sorption takes place rapidly, the Pd being active. If, however, the bulb is exhausted after reduction and then immersed in liquid air no sorption takes place on admitting hydrogen. On removing the liquid air and allowing the Pd to attain the ordinary temperature, sorption again begins after a short lapse of time and soon attains its normal rate. If the hydrogen sorbed is expelled at a dull red-heat, the Pd is no longer active towards that gas at the ordinary temperature. It thus appears that active Pd is inactive at liquid-air temperature, and that immersion in liquid air tends to retard the activity at the ordinary temperature, and to some extent to lower the sorption value. The longer the period of cooling in liquid air the greater is the "lag" in the activity of the palladium, that is, the Pd is made temporarily passive to hydrogen at the ordinary temperature, the period of passivity depending on the duration of cooling. Even cooling at 0° will make the Pd temporarily passive, but after a time sorption begins at that temperature, the rate of sorption finally increasing to the normal one. Even at 0°, however, it was found possible to obtain palladium which was inactive for 48 hours. Equilibrium pressures at 0° were determined as follows: The Pd was oxidised by heating in air for 30 mins., the bulb immersed in an ice-bath, and, after ten minutes, exposed to successive quantities of hydrogen, equilibrium being attained after each addition. These equilibrium pressures (P_{AD}) represent those of "adsorbed" hydrogen. The hydrogen was then removed in successive stages and the equilibrium pressures determined (P_{AB}) after each removal; these pressures represent those of the "absorbed" hydrogen, that is, of the dissolved hydrogen. It is found that the relation $\sqrt{(P_{AD})} = P_{AB}$ holds approximately.

The final conclusions are, that: (*a*) below 0° there is adsorption only; (*b*) between 0° and 150°, adsorption is followed by absorption; (*c*) above 150° there is absorption only. T. S. P.

776. *Influence of Ions on the Electrification and Rate of Diffusion of Water through Membranes.* **J. Loeb.** (Nat. Acad. Sci., Proc. 5. pp. 440–446, Oct., 1919.)—In certain cases water is able to diffuse from solutions of higher to solutions of lower concentrations, and it has been suggested that these phenomena are due to electrical forces caused by the presence of electrolytes in solution, *i.e.*, that differences of electrical potential on both sides of the membrane influence the rate of diffusion of water through the membrane (electrical endosmose). The influence of electrolytes on the rate of diffusion of water through collodion bags was therefore investigated by filling the bag with the solution and dipping it into distilled water. The initial rate of diffusion of water was influenced in a different way by electrolytes and non-electrolytes; solutions of non-electrolytes, *e.g.*, sugars, acted in proportion to their concentration, but only when this was above M/64, no effect being produced at lower concentrations. Solutions of electrolytes show this effect at higher concentrations, *e.g.*, above M/16 or M/8, but at lower concentrations they have a specific influence on the rate of diffusion which is not found in the case of non-electrolytes.

Neutral salts and alkalies with a monovalent or bivalent kation act as if the water were charged positively and were attracted by the anion and repelled by the kation, the effects increasing with the valency of the ion and diminishing as its "radius" increases. Neutral or acid salts with a bivalent or quadrivalent kation act as if the water were charged negatively; acids and neutral salts with monovalent and bivalent kations act in the same way in strongly acid solutions.

The rate of diffusion due to salts of the alkalies increases up to a concentration of about M/256, but then diminishes to a minimum about M/16.

This influence of the concentration of electrolytes upon the rate of diffusion of water explains the phenomenon of negative osmosis. It had been known for more than fifty years that solutions of tartaric and oxalic acids, when separated from pure water by a membrane of pig's bladder, produce a negative osmosis, *i.e.*, water diffuses from the solution to the pure solvent. This holds with certain exceptions for all acids and alkalies, *and negative osmosis occurs in exactly the same range of concentrations where the drop in the electrostatic attraction of sodium salts for water occurs, namely in concentrations from about* M/256 *to about* M/8.

T. M. L.

777. *Equilibria Across a Copper Ferrocyanide and an Amyl Alcohol Membrane.* **F. G. Donnan** and **W. E. Garner.** (Chem. Soc., J. Trans. 115. pp. 1313–1328, Dec., 1919.)—The equilibrium has been studied across a copper ferrocyanide membrane of

(*a*) $K_4FeC_6N_6$ and $Na_4FeC_6N_6$
(*b*) $Na_4FeC_6N_6$ and $Ca_2FeC_6N_6$
(*c*) $Na_4FeC_6N_6$ and $Am_4FeC_6N_6$

at concentrations of about 0·025N. In the first case the results were in good agreement with theory which requires that

$$[Na_1^{\cdot}]\,[K_2^{\cdot}] = [Na_2^{\cdot}]\,[K_1^{\cdot}],$$

where the symbols indicate molar ionic concentrations.

In the second case, however, a closer agreement was obtained when using molar instead of ionic concentrations.

In order to test a liquid membrane it was hoped to take advantage of the solubility of lithium chloride and the insolubility of potassium chloride in amyl alcohol to set up a cell of the type

KCl, LiCl in water | Amyl alcohol | LiCl in water

The rate of diffusion of lithium chloride in amyl acohol was, however, too slow and the problem was studied indirectly by making determinations of the distribution of lithium chloride between amyl alcohol and water with and without potassium chloride.

The concentrations of the ions and of the undissociated part of the electrolyte were calculated, using Green's values for the degree of ionisation of lithium chloride, and the results were in fairly satisfactory agreement with theory, especially when the total concentration of the electrolytes was below 5N.

From the distribution-coefficients of lithium chloride between water and amyl alcohol, it appeared that double molecules were formed in the latter solvent. T. M. L.

778. *Form of the Conductance Function in Dilute Solutions.* **C. A. Kraus.** (Am. Chem. Soc., J. 42. pp. 1–18, Jan., 1920.)—Washburn [see Abs. 433 (1918)] has criticised adversely the function employed by Kraus and Bray [see Abs. 785 (1914)] in determining by extrapolation the limiting value of the conductivity at zero concentration. The author shows that Washburn's graphic method of extrapolation is inconsistent with the assumptions made and that the numerical results obtained by Washburn and Weiland [see Abs. 433 (1918)] agree as well with Kraus and Bray's function as with that of Washburn. T. H. P.

779. *Ionisation of very Dilute Electrolytes.* **G. N. Lewis** and **G. A. Linhart.** (Am. Chem. Soc., J. 41. pp. 1951–1960, Dec., 1919.)—The depression of the freezing-point of dilute strong electrolytes can be expressed very accurately by means of the equation $\log (n\lambda - \theta/c) = \alpha \log c + \log \beta$, where n is the number of molecules produced by complete ionisation of one molecule of solute, λ is the theoretical molal lowering and θ the actual lowering of the freezing-point, and c the number of mols. of solute in 1000 gm. or 55·5 mols. of water; α and $\log \beta$ are constants characteristic of the particular electrolyte. The equation may also be written $n\lambda - \theta/c = \beta c^{\alpha}$, or $\theta = \lambda nc - \beta c^{\alpha+1}$. By differentiating and combining with the thermodynamic equation

$$\int d\ln x = \frac{1}{n\lambda} \cdot \varrho \cdot \frac{d\theta}{c},$$

where x is the mean activity of the ions, an equation is deduced whereby the coefficients of ionisation can be deduced and compared with the values λ/λ_0 calculated in the ordinary way from conductivity data. The results in some typical cases are as follows:—

$C = 0{\cdot}01\text{M}.$

	KCl.	NaCl.	KIO_3.	$NaIO_3$.	K_2SO_4.	$BaCl_2$.	$CdSO_4$.	$CuSO_4$.	$La(NO_3)_3$.
γ . .	0·925	0·925	0·872	0·872	0·687	0·716	0·338	0·290	0·571
λ/λ_0	0·941	0·936	0·928	0·917	0·872	0·883	0·614	0·629	0·802

T. M. L.

780. *The Electro-Affinity of Aluminium.* I. *Ionisation and Hydrolysis of Aluminium Chloride.* **J. Heyrovsky.** (Chem. Soc., J., Trans. 118.

pp. 11–26, Jan., 1920.)—Aluminium chloride is a strong electrolyte yielding the ions $AlCl^{\cdot}_{2}$, $AlCl^{\cdot\cdot}$, $Al^{\cdot\cdot\cdot}$, and Cl'. The molecules possess more affinity for water than for each other, complexes are not known ; the three kations combine with 1, 2, 3OH respectively, but the dissociation does not exceed 3·8 per cent. at high dilution. Potential measurements are made after Tolman, Ferguson, and Acree with cells of the type Hg | calomel solution of $AlCl_3$ | H_2(Pt), using platinised glass electrodes in hydrogen. The hydrolysis determinations agree with Klabukov and Sachanov ; the heat of ionisation of the hydroxide is calculated after Kulgren and the diffusion potential after Henderson. The ionisation of the chloride into chloride-ions is about 20 per cent. less than that of KCl of equivalent concentration ; the mobility of $Al^{\cdot\cdot\cdot}$ is $3 \times 49 \cdot 2$, that of $AlCl^{\cdot\cdot}$ 2×47. II. *The Aluminium Electrode* (*Ibid.*, pp. 27–36, Jan., 1920.)—Aluminium has been assigned various positions in the voltaic series because the metal, unless amalgamated, is passive owing to an oxide film and behaves somewhat like a gas electrode, being sensitive to oxidising and reducing agents and anions, as is shown. In concentrated sulphuric acid the metal slowly liberates hydrogen and is coated with yellow or orange sulphur. In hydrochloric acid or caustic alkali the metal is active and decomposes water vigorously. The amalgam prepared by boiling the metal in pure dry mercury for several hours did not contain more than 0·1 % Al ; the amalgam at once decomposes in moist air. Measuring the potential of the liquid amalgam in different solutions the author derives a potential of — 1·337 volts at 25° against the hydrogen electrode, the reaction being $Al + 3OH' \longrightarrow Al(OH)_3 + 3 \ominus$. H. B.

781. *Reproducible Liquid Junction Potentials : The Flowing Junction.* **A. B. Lamb** and **A. T. Larson.** (Am. Chem. Soc., J. 42. pp. 229–237, Feb., 1920.)—It is shown that liquid junctions formed between the bearing surfaces of ground glass stoppers, in gelatine diaphragms and in parchment paper diaphragms, using 0·1-N solutions of hydrogen chloride and potassium chloride in contact with each other, are not constant and reproducible to closer than 0·2 or 0·4 millivolt. Parchment diaphragms, with stirring, give better results, but still not satisfactory. In tubes of 5 mm. bore, fresh junctions, formed by running out about 1 cm.^{3} of the one solution into the main bulk of the other, give potentials reproducible to about ± 0·03–0·06 millivolt in 0·1-N solutions when oscillations of the electrolyte are prevented, but with N/1 solutions variations of ± 0·3 millivolt occur. Stirred junctions [compare Cumming, Trans. Faraday Soc., 9, p. 174, 1913] sometimes give very constant potentials, but these are quite different from that produced by a " flowing " junction and the values depend on the mode of stirring, etc. Constant potentials, reproducible to ± 0·01 millivolt even with normal solutions, are obtained with a " flowing " junction, which may be made either by allowing the lighter electrolyte to flow constantly into a large volume of the heavier electrolyte, or by having an upward current of the heavier electrolyte meet a downward current of the lighter electrolyte in a vertical tube at its point of union with a horizontal outflow tube. T. S. P.

782. *The Cell Cu or Cu-Amalgam | $CuSO_4$–Hg_2SO_4 | Hg studied Electrochemically and Thermochemically.* **L. W. Öholm.** (Nobelinst. Meddel. [Arrhenius Festskrift], 5. 4 [20 pp.], 1919.)—The research forms part of an investigation of normal cells, and the methods were the same as those used for cadmium cells. The temperatures were 0, 10, 15, 17, 22, 25, 30°. In the first series 4 cells were tested for 3 months, one with a copper wire as electrode, the others with copper amalgam, prepared after Cohen. In the second series, a year later, 3 new cells were tested. The e.m.f. decreased very slightly at first, but kept fairly constant; a lowering of the temperature by 5 deg. disclosed a lag in the e.m.f., but not of a serious kind. On the whole the agreement between the cells was good. The calculations were partly made by the aid of Nernst's theorem. The calculations yield E = 0·3529 volt, the observations give the mean E = 0·3500 volt, at 20°. H. B.

783. *Hydrogen Overvoltage.* II. *Applications of its Variation with Pressure to Reduction, Metal Solution, and Deposition.* **D. A. MacInnes** and **A. W. Contieri.** (Am. Chem. Soc., J. 41. pp. 2013–2019, Dec., 1919.)—In the previous paper [see Abs. 973 and 1447 (1919)] an equation was developed showing the relation between the hydrogen overvoltage (E) at a platinised Pt electrode, the radius, r, of the bubbles formed, the pressure p, and the surface tension γ; the equation was $2FE = 3\,RT\gamma/pr$. This equation is now shown to be in accordance with the results obtained by Goodwin and Wilson for the overvoltage at a nickel electrode. According to the equation the overvoltage should be inversely proportional to the pressure, and the following deductions with respect to various chemical processes can be made. (1) The rate of solution of a metal in an acid, hydrogen being evolved, should decrease when the external pressure is diminished. This was shown to be the case when Zn, Fe, and Cd dissolve in N-H_2SO_4. Inversely, increase in pressure increased the rate of solution of Fe in 0·5 N-HCl. (2) The efficiency of the reduction of ferric chloride solution by metallic iron should increase with diminution in the external pressure. This was shown to be the case. (3) The efficiency of the electrolytic deposition of zinc from a solution of zinc sulphate should increase with diminished external pressure. This was also supported by experiment.

The theory, given in the previous article, explaining the fluctuation of overvoltage accompanying the evolution of a single bubble from a platinum electrode is discussed more fully. T. S. P.

784. *Electrochemistry of Uranium and the Single Potentials of some Oxides of Uranium.* **C. A. Pierlé.** (J. Phys. Chem. 23. pp. 517–553, Nov., 1919. Chem. News, 120. pp. 1–4, Jan. 2, 1920, *et seq.*)—In aqueous solutions, with low current density, uranyl salts deposit first the hydrated uranic oxide, UO_3, H_2O, which is later changed by the action of the current to a black oxide of varying composition. With a higher current density uranyl sulphate is reduced to uranous sulphate, but in the presence of free acid the deposit obtained is small in amount and poorly adherent, although metallic in appearance. In neutral or alkaline solution the deposit formed is a mixture of the black and yellow oxides. The use of a porous pot as a diaphragm leads to no better results; the deposit is the same in character as when no diaphragm is used. The deposit obtained when alkaline uranyl tartrate and citrate solutions are electrolysed is an oxide much richer in uranium than that deposited from solutions acidified with tartaric or citric acid. The conductivity of non-aqueous solutions (in ether, ethyl acetate, amyl alcohol, pyridine, acetone) of uranyl salts is a function of the water present, and the deposits formed are oxides contaminated with organic matter. Anhydrous pyridine treated with anhydrous uranium tetrachloride forms solutions conducting electricity. From these deposits a compound containing uranium and pyridine may be obtained at the kathode. Anhydrous acetone, when used as a solvent for uranium tetrachloride, gives a solution which conducts well, but deposits no pure metallic uranium. The deposit replaces mercury from mercurous sulphate. The uranium tetrachloride reacts with acetone, forming 2:2-dichloropropane and also further decomposes acetone. Hydrogen is evolved during the electrolysis of the solution. Solutions of potassium uranyl fluoride, whether neutral, acid, or alkaline, form a deposit containing fluorine. In acid solution the deposit is UF_4, $6H_2O$. Neutral or alkaline solutions give a mixture of UF_4 and uranium oxide. Deposits from neutral potassium uranyl cyanide solutions consist of potassium uranate. When the solutions are acid with hydrocyanic acid, the deposit is the yellow hydrated oxide contaminated with some of the black oxide.

It is demonstrated that the single potentials of metal and oxides in powder form can be measured accurately by pasting the finely powdered material on a platinum electrode with gelatine. The single potentials of the more stable oxides of uranium were measured, against a solution of uranyl nitrate (14·3 gm. per litre), with the following results: U_3O_8, − 0·778 to − 0·787 volt; UO_2, − 0·773 to − 0·778 volt; the black oxide gave potentials varying from − 0·4999 to − 0·302 volt. This black oxide, which is formed when uranium salts are electrolysed, is not U_3O_8, $2H_2O$, as has hitherto been claimed, but U_3O_{10}, $2H_2O$; this is verified by its different potential from that of U_3O_8. The position of uranium in the electrochemical series has not been definitely fixed, because pure uranium has not been obtained, but the max. potential of a sample of uranium containing 91·49 % U and 8·34 % of ferric oxide was found to be − 0·093 volt. The potential decreases rapidly in contact with the uranyl nitrate solution, indicating a rapid oxidation of the metal.

Experiments were also made on the electrolysis of baths of fused potassium sodium uranate, and of a fusion of potassium nitrate and uranyl nitrate. Solutions of uranyl acetate were also electrolysed.

T. S. P.

785. *Electrolytic Determination of the Halogens: An Indirect Method.* **J. H. Reedy.** (Am. Chem. Soc., J. 41. pp. 1898–1902, Dec., 1919.)—The estimation of the halogens by their electrolytic deposition on silver anodes is unsatisfactory because the silver anode begins to dissolve, either during the last stages of the electrolysis, or immediately upon completion of the halide ion deposition. Making use, however, of the fact that the decomposition potential of a 0·5M–H_2SO_4 solution saturated with silver chloride is 0·59 volt, when silver coated with silver chloride is used as the anode against a bright Pt kathode, the authors obtain quantitative results as follows: The solution of the halide salt in 0·5M-H_2SO_4 is electrolysed with an e.m.f. of 0·59 volt, which is increased to 0·60 volt, as soon as the current has fallen practically to zero, and the current is passed for a further five minutes. The silver anode, with its halogen deposit, is weighed and then made the kathode in a dilute solution of sodium hydroxide, electrolysis being continued until hydrogen is formed freely on the surface of the silver. The silver halide is thus reduced to black silver. The electrode is washed thoroughly and then heated to about 500° in an electric furnace until the deposit is white and thoroughly sintered together, after which it is again weighed. The loss in weight on reduction represents the weight of the halogen. The results obtained were quantitative for chlorides, bromides, and iodides. T. S. P.

786. *Overpotential and Catalytic Activity.* **E. K. Rideal.** (Am. Chem. Soc., J. 42. pp. 94–105, Jan., 1920.)—It is suggested that overpotential is a measure of the energy required for the desorption of hydrogen from a metallic surface. Metals with low latent heats of desorption are catalytically active, the activity increasing with decreasing overpotentials. Metals with overpotentials exceeding 0·445 volt are catalytically inert and no metal can possess an overvoltage exceeding 1·80 volts. In accordance with this hypothesis it is shown that the calculated values of the catalytic activities of the metals are in agreement with Sabatier's qualitative observations. A tentative suggestion for the mechanism of the process of desorption, which is based on the radiation hypothesis [see Abs. 814 (1919)], is put forward by the author. The results of experiments on the influence of temperature on overpotential at electrodes of platinum, copper, and zinc are given, but there is not a good agreement between the observed value of the temperature coefficient and that calculated on the assumption that the overvoltage is a simple function of the bubble size. In the case of copper the relation between the overpotential and (1) the electrode surface, (2) the catalytic activity was also investigated. There was a continuous fall in the value of the overpotential as the bright crystalline appearance of the metal was replaced by a honey-comb amorphous layer; at higher temperatures this fall took place more rapidly than at lower temperatures. No direct relationship could be found between overpotential and the temperature of apparent catalytic activity towards a hydrogen-oxygen mixture of a strip of copper which had been alternately oxidised and reduced; in all cases, however, the overpotential fell with the temperature, that is, with the increase of catalytic activity. T. S. P.

787. *Phenomena after Anodic Polarisation.* I. **A. Smits, G. L. C. La Bastide, and J. A. van den Andel.** (K. Akad. Amsterdam, Proc. 22. 1. pp. 82–88, 1919.)—The authors have studied the phenomena which take place after anodic polarisation of various metals, the potentials being measured, not during the passage of the current, but immediately after the current had been broken by a rotating commutator. In the case of iron and nickel, as was previously found for chromium by Aten [see Abs. 882 (1918)], when the current density used is not so great that the metal becomes passive, it shows a more strongly negative potential just after the current is broken, than it did before it was polarised. Thus when iron in N/2 $FeSO_4$ solution is polarised with a current density of 0·360 amp./cm.^{2}, immediately after breaking the current the potential of the anode falls to 90 millivolts less than it was before the polarising current was put on. The potential rapidly rises and regains its original value in a few seconds. Nickel behaves similarly to iron. Silver and copper electrodes behave normally, so that abnormal behaviour only occurs after anodic polarisation in the case of iron, nickel, and chromium. The abnormal behaviour of iron disappears when a solution of ferrous chloride is used which has been boiled for a long time with iron powder in an atmosphere of hydrogen, giving an electrolyte with which the metal is in a state of internal equilibrium. T. S. P.

788. *Influence of Superposed Alternating Currents on the Anodic Formation of Ferrates.* **G. Grube** and **H. Gmelin.** (Zeits. Elektrochem. 26. pp. 153–161, April 1, 1920.)—Salts of ferric acid have been prepared by three methods, namely:—By Fremy, who fused iron with saltpetre and also passed chlorine into a caustic potash solution containing ferric hydroxide in suspension; then by Poggendorf, who obtained deep-red solutions of ferrates by the anodic polarisation of a cast-iron electrode in caustic potash solution. Haber and Pick found later that other forms of iron are converted at the anode into ferrates, that caustic soda is better than caustic potash, and that the yield is improved by diminishing the current density, by elevation of temperature, and by increase of alkali concentration. During electrolysis the iron tends to become passive and coated with an oxide layer, so that ferrate formation decreases and eventually only oxygen is evolved. Haber and Pick prevented this by a periodic change of current. The present authors find that in order to obtain concentrated solutions of ferrates, the experimental conditions must be so arranged that the velocity of electrolytic formation of ferrates is appreciably greater than the velocity of hydrolytic decomposition. To attain this object two methods present themselves: (1) To make the quotient, Current strength/Volume of anode solution, as great as possible. (2) To find the requisite current densities by trial. The conditions are compared with the electrolytic refining of gold containing silver. The authors now show that a superposed alternating current with a high direct-current density promotes not only the formation of saturated ferrate solutions, but admits of the crystallised salts being obtained. Section 2 describes the experimental conditions with illustrative diagram. Section 3 details experiments with anodes of commercial sheet iron, while Section 4 deals with ferrate formation at anodes of electrolytic iron. Section 5 is devoted to a discussion of the results. Increase of temperature and of alkali concentration favour ferrate formation. With increasing current density, the yield of ferrate was found to pass through a maximum.

The yield of sodium ferrate was found to be considerably enhanced by the superposition of an alternating current at the anode. The increase in yield per constant direct-current density attains a maximum at a quite definite density of alternating current. When 40 % caustic soda solution is employed as electrolyte at 35° C. with a d.c. density of 3·33 amps./dm.^{2}, the max. yield was attained when an a.c. density of 5·0 amps./dm.^{2} was used. Under these conditions *an increase in yield was obtained of* 160 % over that using the direct-current electrolysis alone. For the production of concentrated ferrate solutions the anode and kathode must be separated by a diaphragm to avoid kathodic reduction. Since ferrates at temperatures above 50° C. decompose with evolution of oxygen and separation of ferric hydroxide, this temperature must not be exceeded, so that concentrated ferrate solutions can only be obtained by high direct-current densities.

The paper includes 10 tables of data. H. H. Ho.

789. *Alternating-Current Electrolysis.* **S. Marsh.** (Roy. Soc., Proc. 97. pp. 124–144, April 1, 1920.)—The two electrodes, sealed into glass tubes, were introduced through the stoppers in opposite ends of a horizontal glass tube, 5 cm. in diam., containing the electrolyte. Above each electrode, and sealed into the horizontal tube, was a graduated and

stoppered tube for measuring the gas evolved. A third tube sealed into the graduated tube acted as a feed tube for the electrolyte. In order to measure the potential drop in the neighbourhood of the electrodes during the experiment, explorers, each consisting of a very fine Pt wire, sealed into a glass tube, were introduced in the neighbourhood of each electrode.

Platinum Electrodes.—With 105 volts at 40 cycles, using Pt electrodes and approximately N/1 H_2SO_4, the rate of gas evolution is not uniform, but falls off rapidly, finally ceasing altogether. Simultaneously the Pt changes from its usual appearance to a dull black, or greyish black. Using different frequencies ($n = 25$ to $n = 80$) the curves showing the relation between the volume of gas given off and the time, resemble the saturation curves in radio-activity, and the relation between the log. of the volume and the log. of the frequency is a straight line, that is, $V_n . n^\beta = C$, where V_n is the volume at the frequency n. For Pt foil of thickness 0·21 mm. β and C are respectively 2·6 and $1{\cdot}406 \times 10^5$, whilst for foil of thickness 0·11 mm. the values are 2·6 and $7{\cdot}889 \times 10^4$. The volumes given off from the thin foil were approximately half those from the corresponding experiments with thick foil, but experiments with foils of different thickness showed that the relation is not of such a simple nature as that just given. Using Pt electrodes of the same thickness, but of different area and the same strength of current (1 amp., 30·5 cycles), it was found that the relation between the log. of the volume of gas and the log. of the area is a straight line, the relation being $VS^a = b$, where $S =$ area, $a = 1{\cdot}403$, and $b = 26{\cdot}55$. For the same current density the total volume of gas liberated by an electrode is proportional to its area, the frequency being constant throughout.

Gold and Nickel Electrodes.—With gold electrodes gas was still being given off for a much longer time than with platinum, when the frequencies were less than 48, the curves not resembling saturation curves. With nickel electrodes the gas evolved was entirely hydrogen; copious evolution took place until the electrode fell off owing to dissolving in the acid. With approximately N/10 barium hydroxide as electrolyte, gas is continuously evolved at gold and platinum electrodes, the volume–time curves showing no approximation to the saturation type. With nickel electrodes only traces of gas are evolved.

The above results are discussed in a theoretical part of the paper, two suggestions being put forward to explain the phenomena: (*a*) the oxidation of the electrode, coupled with subsequent reduction by the hydrogen in the next half-period, (*b*) the absorption and adsorption of hydrogen by the electrode, coupled with recombination with oxygen in the next half-period. These processes are not mutually exclusive, and it is possible that both agencies are operative in degrees varying with the metal employed. [Compare Abs. 1233 (1904).] T. S. P.